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Abstracts and Papers from the 38th Western Society of Malacologists Meeting

Contributed Paper

Phylogeny and Biogeography of the Atlantic and Eastern Pacific *Hypselodoris* Stimpson, 1855 (Nudibranchia, Chromodorididae), with the Description of a New Species from the Caribbean Sea

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A new species, based on two specimens collected from Guana Island, British Virgin Islands is described. The new species agrees with the genus *Hypselodoris* in having a high body profile, a large vestibular gland, and mantle glands. The new species externally differs from other members of the genus in the Atlantic Ocean by having a reddish background body color. In addition, dorsal color patterns such as a broad central white line with lateral extensions and the lack of yellow lines or spots further differentiate this species. Internally, the radular formula of 52 x 41.0.41 and a smaller seminal receptacle offer distinctive features for this species. The phylogenetic relationships of 34 species and subspecies of *Hypselodoris* from the eastern Pacific and Atlantic are examined using morphological characters. With the exception of the new species, all these species are characterized by having a dark blue background body color. The phylogenetic analysis of the data matrix resulted in eight most-parsimonious trees. The resulting consensus tree shows that eastern Pacific and Atlantic species of *Hypselodoris* constitute a monophyletic group, which is basally split into two sister clades. One clade contains the eastern Pacific species and most of the Caribbean species, whereas the other clade contains the eastern Atlantic species. The new species is sister to the rest of the Caribbean species, which are also a monophyletic group.

A Unique Deep-Water Molluscan Ecosystem from the Northwestern Slope of the Great Bahama Bank

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Three successive deep water surveys of the northwestern margin of the Great Bahama Bank, in the vicinity of Victory Cay (Bimini chain) were conducted during years 2001, 2002, and 2003 from the Florida Institute of Oceanography (FIO) research vessels "Bellows" and "Suncoaster." The surveys were conducted using a fixed frame 1.0' x 3.0' Cape Town dredge at depths of 200-600 meters. Eighty-one species of mollusks belonging to 40 families have been collected and identified, many of which are rare or endemic to the Bimini Islands vicinity. Dredged material consisted of two main components: (1) dead and eroded remains and complete shells of shallow water mollusks that resulted from post-mortem transportation down the steep slope of the Bahama Platform and (2) live deep sea mollusks inhabiting a unique slope ecosystem. The dominant species of this relatively unknown ecosystem are: *Conus (Lindaconus) lindae* (Petuch, 1987), *Tugurium caribaeum* (Petit, 1856) and a new species of *Scaphella* cf. *S. gaudiati* Bail et Shelton, 2001. A number of factors are found to control the existence of this

unique assemblage including, but not limited to, the distinctive slope topography of the northwestern margin of the Bahama Bank, and a Gulf Stream funneling effect which alters current structure and velocity at this narrowest portion of the Florida Strait causing an asymmetrical water temperature profile from west to east across the Strait of Florida.

Detecting and Interpreting Morphologic Constraint in the Fossil Record

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At all taxonomic levels, from Baupläne to morphospecies, morphologic variation is neither randomly nor evenly distributed. This pattern is the product of adaptation, constraint, and plasticity acting on populations in ecological time and on lineages in evolutionary time. Because lineages can maintain their morphologic identity over millions of years and numerous speciation and extinction events, constraint is critical to macroevolution.

The Corbulidae (Bivalvia) is a morphologically diverse clade containing several morphologically conservative subclades that provide an opportunity to examine the role of constraint in evolutionary history. For the *Caryocorbula* + (*Bothrocorbula* + *Hexacorbula*) clade, all from Caribbean Neogene deposits, each genus is morphologically distinct both in shape and size. In addition, *Caryocorbula* morphospecies exhibit strong interspecific allometry that persists despite repeated speciation and extinction, as well as the vagaries of geographic and temporal sample coverage. In spite of the conservative morphology within this basal clade, more derived corbulid clades subsequently occupied new areas of morphospace.

Paleontologic data allow morphology to be examined in a geographic by temporal matrix over evolutionary time scales. For extinct taxa, whose diversity far exceeds that of extant members in many molluscan clades, the fossil record is the only source of information on evolutionary patterns. Thus, although it is often not possible to identify causes of morphologic constraint (e.g., pleiotropy vs. stabilizing selection), the fossil record provides the opportunity to examine morphologic response to changing environmental conditions over evolutionary time both within and among species.

Results of the Giant Pacific Octopus Census in Puget Sound, 2000-2005

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A scuba diving survey was organized on 19 February 2000 by the Seattle Aquarium in Puget Sound (Washington State, USA) to establish a baseline of how many giant Pacific octopuses (*Enteroctopus dofleini*) there were in the area and to determine if the population was

healthy. Information requested from the volunteer divers was location, depth, time, description of dens, and an estimate of size. There were 18 octopuses spotted that day by 114 divers looking at 19 popular dive sites where octopuses had been seen historically. Four octopuses were females guarding eggs. Since then, the census was increased to the three days over a holiday weekend with increased participation and increased octopus sightings. In 2005, 210 divers reported seeing 61 octopuses, none in southern Hood Canal. Implications of the results of this census in relation to behavior, life history, and biology of these octopuses, environmental changes, presence of marine preserves and possible harvest limits are discussed.

The Packaging Problem: Bivalve Prey Selection and Prey Entry Techniques of *Enteroctopus dofleini* (Cephalopoda: Octopodidae)

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When an octopus finds a clam its problems with getting at the food inside are not over, as it still has to get between the hard shells. When *Enteroctopus dofleini* was offered the mussel *Mytilus trossulus* and the clams *Venerupis philippinarum* and *Protothaca staminea*, it solved the penetration problem differently for each prey species. Octopuses usually pulled apart the shells of *Venerupis*. Thinner *Mytilus* shells were equally often broken, chipped at the edges, or pulled apart. The thicker *Protothaca* shells were chipped or had a hole drilled in them with the radula and the salivary papilla. Tests of clam strength showed *Protothaca* the strongest in holding their shells together. When *Venerupis* shells were wired shut, the octopuses resorted to chipping or drilling instead of pulling. Thus these octopuses have four ways of getting into a clam, and used the easiest method possible, resorting to drilling only when other methods were unsuccessful.

Monospecific Fossil Assemblages: Distinguishing Between Accumulation and Aggregation Using Phylogeny and Paleobiology

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Dense monospecific assemblages are common in certain living and fossil molluscan taxa such as turritellid gastropods, pectinid bivalves, and corbulid bivalves. These occurrences can be attributed to physical or biological factors. Physical factors leading to monospecific accumulations are generally post-mortem and include winnowing, dissolution, and transport. Biological factors leading to monospecific aggregations generally relate to recruitment and development. Detailed field and laboratory examination of the fossils can refute hypotheses related to physical factors, but often are equivocal for hypotheses related to biological factors,

particularly for taxa with features suggestive of indirect development. Biological factors are better tested with paleobiology and extant phylogenetic bracketing. Bracketing is particularly useful in clades that vary in their tendency to form monospecific aggregations, such as corbulid bivalves. Living corbulids such as *Varicorbula disparilis* form large byssally-attached masses, and their close fossil relatives (e.g. *Varicorbula caloosae*) tend to be found in monospecific aggregations. Other shallow-burrowing corbulids in which the byssus plays a less important role, such as *Corbula contracta*, are rarely found as aggregations. Once the biological origin for an aggregation has been established, we can begin to address related questions including why it occurs in a particular place and/or time.

Extinction and the Life History of Unionid Bivalves

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Freshwater mollusks are disproportionately represented among recent extinctions. In North America, estimates of historical extinctions of freshwater bivalves (Unionidae) range from 21-37 species, or about 10% of the pre-settlement fauna. Many more extinctions are impending. Reasons for this decline are complex and mainly involve anthropogenic habitat destruction and fragmentation. The dependence of unionids on particular species of fish as hosts for parasitic larva development is an unusual example of "habitat" specialization that may contribute to vulnerability and that complicates efforts to define diversity and conservation priorities. Recent studies of host specificity indicate that some morphologically defined unionid species consist of multiple species or at least host races, which are differentiated by their adaptation to sympatric host fish species and populations. Such differentiation is expected to be most pronounced in mussels that utilize geographically fragmented and genetically diverse host populations. In the unionid morphospecies *Cyprogenia aberti*, for example, mussel populations in different drainages are able to utilize local populations of several species of darters (*Etheostoma, Percina*) but generally not populations or species from other drainages. Both host specificity and genetic evidence indicate that *C. aberti* consists of 3-4 species. Reliance on particular host species or populations probably increases extinction risks for unionids because they share vulnerabilities of the host species as well as their own. However, the hypothesis that host abundance, host genetics, or particular aspects of the host-parasite relationship are responsible for unionid declines is generally untested.

Gametogenesis and Fecundity of *Atrina maura* in Laguna de San Ignacio, Baja California Sur, México

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Pen Shell, *Atrina maura*, fisheries in Baja California peninsula increased lately, so it is important to study fisheries development and the knowledge of its reproductive process for natural populations management for sustainable exploitation and to establish the seed production in laboratory. San Ignacio Lagoon, Baja California Sur, is the most important capture zone. From 2000 2003, Monthly, meristic data, volumetric condition (IC), & muscle yield (IRM) indices were obtained, and oocyte diameters measured of seven individuals. Seston and temperature were recorded. Seston values were not related to temperature during the study. Values were high due to the oligotrophic nature of the lagoon. We found a small relationship between IC and IRM, nevertheless, while IC indicates increase in the body volume in valvar cavity in winter and spring, gametogenesis never stopped. IC is not a positively linked index to the gonadic maturity. Inverse relationship between IC and IRM suggests that when size muscle increases, the body volume decreases. Years 2000, 2002 and 2003 showed continuous spawns and all stages of oocytes. But 2001 showed no oocytes in reabsortion stage, suggesting the gonad acts like a store organ. This sets *A. maura* like an opportunistic species assuring its reproduction and basal metabolism. Fecundity showed more than 1000 million mature oocytes and 15,000 $x10^9$ spermatozoids. These values seem very high, however they correspond to the total number of gametes inside the gonad (weight 100-400g), and not the ones that are spawned due to assure the survival of the species.

Reproductive Effort of *Atrina maura* in Laguna de San Ignacio, Baja California Sur, México

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There are many available qualitative studies describing reproductive cycles in bivalves, but few quantitative data to observe reproductive effort because of the complexity of its gonad; however, they are important for growth modelization, fishery, biology, and natural populations management for sustainable exploitation. To solve this problem, we present an original method associating histology, stereology and image analysis techniques determining in a quantitative way the gonadic growth in bivalves. From 2002 to 2003 stereology (Cavalieri's principle) was used, and biochemical analyses were determined for energetical values to give the reproductive effort in seven organisms of *Atrina maura*. Gonadal tissue occupational percentage and volume was predominant, followed by digestive gland. Both springs showed superior values. Gonad biomass constitutes a quantitative gonadic index showing the development of the annual

reproductive cycle in this species with developed gonad in spring. The main total energy contributors in *A. maura* were gonad and digestive gland, while muscle was always low. Reproductive effort represents 200% of total energetic content of the animal. Warm temperatures seem to be the reason. Traditional methods would not confirm gametogenesis through the year accurately. This tool gives us a different scope to find out with precision the period of the year when the most important reproductive event takes place. The difficulty of distinguishing the reproductive periods in species like *A. maura* that are subject of commercial overexploitation makes them fragile and moves them away from a sustainable practice. This work seeks to establish the ban on collecting during the spring season to develop a sustainable fishery.

Morphological and Behavioral Defenses in Three Species of Whelks in the Genus *Nucella*

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In contrast to the numerous studies that have examined gastropod shell defenses and defensive behaviors in isolation, few studies have examined the relationship between antipredator behaviors and morphological defenses (size and shell shape) that influence prey vulnerability. I examined the relationship between antipredator behavior and morphological defense in three closely related marine gastropods in the genus *Nucella*. The three species differ in their degree of morphological defense (shell thickness) and susceptibility to a common crab predator *Cancer productus*. In agreement with other studies, results showed that thinner shelled species were most susceptible to crab predation. In contrast with other studies, the species with the strongest morphological defense did not exhibit the least behavioral avoidance. Instead, the most morphologically defended species also exhibited the strongest behavioral response to crab predator cues. Within a species, small, more vulnerable individuals showed stronger anitpredator behavior than large individuals. Thick- and thin-shelled individuals did not differ in antipredator behavior suggesting no relationship between behavior and shell thickness. Differences in the relationship between defensive traits among and within species suggest that more studies exploring the relationship between morphology and behavior are needed to understand the evolutionary and ecological importance of gastropod responses to predators.

Molecular Systematics of Problematic Unionids

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The combination of high ecophenotypic variation, geographic variation, and rarity in many unionid species have contributed to uncertainty about their systematics. Use of DNA

sequencing of the ITS1, *cox1*, 16S, and *nadh1* regions reveal that *Lasmigona holstonia* as currently recognized is a species complex, with Coosa and Caney Fork system populations both distinct from the Tennessee and New populations. Recognition of species in *Toxolasma* and *Elliptio* has ranged from extreme splitting to extreme lumping; molecular data support an intermediate level of species diversity. *"Obovaria" olivaria* appears relatively distinct from other *"Obovaria"* species, in agreement with Simpson's recognition of a distinct genus for it. *Fusconaia* species show strong biogeographic patterns in their distribution; relationships within the *flava-cerina-askewi* complex remain unclear. Frequent genetic differentiation of populations from different river systems suggests that geographically isolated populations of supposedly widespread species deserve close scrutiny.

Molluscan Faunas and Zoogeography of the Georgia Neogene

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Western Atlantic Neogene marine deposits were notoriously patchy from New Jersey south to the Florida Keys and around the Gulf to the Florida Panhandle. Major gaps in the Pliocene record occurred between Charleston, South Carolina and Daytona Beach, Florida, and again between Tampa and the Panhandle. Middle Miocene outcrops and spoil were found in Maryland, Aurora, North Carolina, and the Florida Panhandle. Literature documented only three macro-invertebrate species from the Miocene, and about forty from the Pliocene of eastern Georgia. Based on our study of the Kirby collection from Brunswick, Georgia, we can now document more than 90 Charlton molluscan species (middle Miocene); over 30 Goose Creek Limestone and 100 Raysor Marl species (early Pliocene); over 100 Duplin species (middle Pliocene); three Waccamaw or equivalent species (late Pliocene), and over 100 Late Pleistocene species. The Charlton fauna shared numerous species with the Chipola fauna from the Panhandle. Both were fully tropical, based on an abundance of *Vasum*, *Turbinella*, and *Melongena*. Only two molluscan species, one coral and a sand dollar were shared with the time equivalent, but cooler, Maryland Miocene faunas. This argued for faunal interchange between the Gulf and Atlantic through the Suwannee Strait during middle Miocene time. In contrast, the Georgia Pliocene faunas more strongly correlated with the subtropical Carolinian province. *Cyclocardia* and *Astarte* were abundant, and the species richness of *Conus* and other gastropods reflected patterns of Carolinian diversity, not the rich tropical diversity recorded from southern Floridian strata.

Systematics and Phylogenetics of the Family Streptacididae (Gastropoda: Heterobranchia) from Devonian through Triassic Marine Strata

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Streptacididae is among the earliest families in the subclass Heterobranchia, an abundant and ubiquitous subclass of fossil and modern Mollusca. In the Paleozoic, the subclass Heterobranchia contains one informal group with two genera and two species in the Early and Middle Devonian, one family with one genus and one species in the Permian, and the family Streptacididae with seven genera and about 85 species from the Middle Devonian to the Triassic and possibly from the Cretaceous. The family Streptacididae is characterized by a heterostrophic protoconch, small size (0.4 to 14 mm), and an elongate shape. Streptacididae survived both the Late Devonian and Permo-Triassic extinctions.

The family Streptacididae is a basal member of the superfamily Pyramidelloidea based on preliminary cladistic analyses. Splitting the genus *Donaldina* into additional genera is not supported by cladistic analyses. Taxonomic assignments are revised based on protoconch morphology, spiral ornamentation, and other shell characters. *Streptacis* and *Donaldina* are considered to be distinct at the genus rather than family rank, and family Streptacididae is assigned to the superfamily Pyramidelloidea. Authors have proposed that the genus *Jiangxispira* was an evolutionary connection between the family Streptacididae and the Mesozoic superfamily Cylindrobullinoidea, which likely were basal opisthobranchs.

Mysella pedroana, Not Another Host-specific Bivalve

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Mysella pedroana (Dall, 1898) lives commensally on *Isocheles pilosus* (Holmes, 1900) and *Blepharipoda occidentalis* Randall, 1839. Specimens attached to *Isocheles pilosus* were previously thought to belong to an undescribed species, because of their small size at reproductive maturity and have been referred to in the literature as *Mysella* sp. H. However, once the variability of dentition and internal structure of small *Mysella pedroana* and *Mysella* sp. H were compared, it was determined that the two were in fact the same species. The prevalence of *Mysella pedroana* was higher on *B. occidentalis* than on *I. pilosus*. Those on *B. occidentalis* were also larger in the gill chambers compared to only juveniles found in the gills of *I. pilosus*. Variability of characters, including size at reproductive maturity and shell morphology, indicates that *Mysella pedroana* is a highly variable species. The identification of this bivalve as *Mysella pedroana* is perhaps due to the continuing research on the symbiont and host relationship. Reported host specificity for commensal bivalves may be due to the lack of study or

experimental observations. This species was previously thought to be host specific, but this assumption has been shown to be invalid.

Reevaluating the Facelinidae: Systematics and Phylogeny

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The goal of my study (Chan) is to complete a phylogenetic analysis of a major family of aeolids, the Facelinidae, and more spe cifically the genus *Facelina*. Many species have been described but no revision is available for Facelinidae or even the genus *Facelina*. At least 15 species of *Facelina* from the Indo-Pacific tropics remain undescribed. The reason why this study will focus on *Facelina* is because this is the most diverse genus of the family, which includes approximately one third of the known species of Facelinidae. Presently, they may not constitute a monophyletic group. Generic boundaries are poorly circumscribed and have not been tested phylogenetically. Many of the existing species descriptions are incomplete or vague. We examine the use of novel anatomical characters such as jaw elements, genital armature, accessory glands and modified cerata in further resolving the distinction between *Facelina* species.

A Preliminary Study of the Biology of *Veronicella sloanei* (Cuvier, 1817) in Barbados

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In Barbados, in the first half of the twentieth century, plant damage caused by slugs was deemed to be "annoying but not economically serious." However, by 1950 slug populations and slug damage appear to have increased, as records show that in 1951 a search for parasites suitable for the biological control of *Veronicella* was undertaken. None were found and today slugs, particularly *Veronicella sloanei*, are still an important pest in gardens and plant nurseries in Barbados. Research into the biology of *Veronicella sloanei* was carried out in the 1980s, but the results were never published and have since been lost. In the present study *ad libitum* sampling of animals in the field, and focal animal sampling and scan sampling of slugs held in aquaria were employed to collect data on the activity budget and mating behaviour of *V. sloanei*. Slugs were examined for the presence of an inflated bursa copulatrix, a condition that, in this study, was used as evidence of prior sexual activity. Egg clutches found in the field and those produced by captive slugs were incubated and the hatchlings were reared in aquaria. Preliminary data reveal that slugs are active, and will feed, throughout the night until just before dawn. Both in the field and in the laboratory, *Veronicella sloanei* was found to mate in pairs, in triplets or in

groups. An inflated bursa copulatrix was most commonly found in animals with a contracted length of greater than 40 mm.

Partula: the Birth and Death of Species

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Partulid land snails have been unusually informative about the mechanisms of speciation, and recently they have become an exemplar of invertebrate conservation. Here we review the evolution and extinction of *Partula* species, with an emphasis on some unanswered, or partially answered, questions:

1) Where did the Partulids come from?
2) What caused the exceptional flowering of color and pattern polymorphisms in Eastern Polynesia?
3) What were the modes of speciation, and how did the species diverge?
4) Why were the Partulids of the Society Islands so susceptible to the introduced carnivore *Euglandina rosea*?
5) How can we save at least some of them?
6) If we cannot save them, what else can we do?

We will give some tentative answers.

Molecular Insights into Biogeographic Patterns of Speciationin Marine Molluscs

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Speciation is generally thought to occur as a result of geographic separation that causes a disruption in dispersal and gene flow between populations. It is difficult to imagine effective geographic barriers to dispersal in the ocean, especially for species with planktonic larvae. However many studies of marine animals, such as echinoderms and fishes seem to support such a pattern of allopatric speciation. Published molecular phylogenetic studies of marine molluscs show that patterns of speciation depend on the taxonomic group and on the region of the world in which the phylogeographic patterns are studied. Research from the Indo-Pacific show a pattern of allopatry between sister species and many small areas of regional endemism and cases with more distantly related species occurring in sympatry. Studies along the Pacific coast of the Americas support a situation where many sister species occur in sympatry. Comparisons across datasets show that those species that occur in sympatry are generally separated by smaller

genetic distances than those that are allopatric but that divergences also correlate across geographic region. This suggests that the tempo and mode of speciation varies geographically.

Partulids on Tahiti: an Interesting Distribution among Surviving Populations

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The extinction of numerous species of endemic land snails in French Polynesia due to the introduction of the carnivorous *Euglandina rosea* is a salutary lesson in panic biological control undertaken without adequate scientific field trials. Less than 20 of the original 70+ species of the family Partulidae survive on maybe a dozen of the original 17 islands which were previously host to partulids. Last year surveys were carried out in over 60 of the valleys of Tahiti. All of the populations found were of the *Partula hyalina/clara* sister lineage which previously accounted for only 5-10% of the individuals collected in scientific studies before the introduction of *E. rosea*. No individuals of the *Partula otaheitana/affinis* complex were found (over 90% of previous collections) in any valleys, yet these species still survive in many montane forest areas (over 1000 m altitude). *Partula nodosa*, with a previous distribution of just 7 valleys, is most likely extinct in the wild but persists well in captive populations. *Partula filosa*, *Partula producta*, and *Partula cytherea* (all previously with a single valley distribution) are almost certainly extinct, as are *Samoana jackieburchi* and *Samoana burchi*. *Samoana attenuata*, also surviving on Moorea, is very rare but widely distributed.

Morphological Variation in Allopatric Populations of *Acanthina* and *Nerita* Gastropods in the Northern Gulf of California

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Geographically separated populations often exhibit distinct phenotypes. These differences could be attributed to changes in environmental conditions among sites, genetic effects between populations, or an interaction of the two (GxE). To address this issue we examined morphological variation in three disjunct populations of two gastropod species, the unicorn snail, *Acanthina sp.*, and a nerite, *Nerita sp.*, near Puerto Peñasco, Sonora, Mexico. The three populations included, (1) Estero Morua, where comparatively large snails were isolated on a coquina limestone island near the mouth of the sandy estero habitat; (2) Punta Peñasco, where smaller snails were wide spread on the basalt boulders in the upper intertidal zone; (3) Punta Pelícano, where small and medium sized snails were clustered on granitic outcrops in the middle intertidal zone. We measured five morphological shell characteristics for *Acanthina* (shell height, shell width, aperture height, aperture width, labial spine length) and eight for *Nerita*

(shell height, shell width, aperture height, aperture width, medial tooth length, lateral tooth length, whorl height, operculum length). Principal components analysis (PCA) showed significant morphological differences among the three populations of *Acanthina* (A=.43, P<.001) and Nerita (A=.68, P<.001); snails from Estero Morua were markedly larger than the other two populations, which were similar in size within each genus. These results suggest that snails in Estero Morua are geographically isolated from the other two locations.

Persistence of a Native Brackish-water Hydrobiid Snail Population in Certain Restored Marshes of Southern Suisun Bay, San Francisco Estuary

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We monitored aquatic invertebrates approximately monthly for over three years (since 1999) and then semi-annually in restored and reference brackish marshes in southern Suisun Bay of San Francisco Estuary. Several sites with marsh tidal pools yielded numerous aquatic invertebrates on modified mesh minnow traps, and thriving hydrobiid snails, related to *Tryonia imitator*, the endangered west coast brackish water snail. Possible identifications are *Tryonia sp.* or *Hydrobia andersoni* (described only from fossils up the ancient San Joaquin River). Core samples taken in mud yielded dead eroded snail shells as deep as 130 cm in the ancient peat soil, indicating these snails are native (due to slow sedimentation rates at this site). Subsequent seasonal sampling for approximately a year (2002-2003) at the same site yielded consistently high densities of snails, an average of approximately 200-300 snails per 25 cm^2 in mud and 60-80 per 25 cm^2 on vegetation. Juvenile snails (represented as snails with shell lengths of < 0.50 mm) occurred in most seasons. In the lab, these snails brooded their young and were observed feeding on filamentous algae, diatoms, and cyanobacteria. They tolerated sudden shifts in salinity and many snails (>2.0 mm shell length) survived for approximately a year in the laboratory. Since these hydrobiid snails persisted for at least ~five years, demonstrated seasonal recruitment, high average seasonal densities for over a year, and were abundant with other aquatic invertebrates, marsh tidal pools seem to be an important feature in restoring common, persistent, and possibly ancient assemblages of native aquatic invertebrates.

Predation by *Euglandina rosea* on Local versus Non-local Gastropods: No Differences in Mucus Trail Following?

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Carnivorous snails, such as *Euglandina rosea*, have been used unsuccessfully as biocontrol agents in Hawai'i and other Pacific islands in an attempt to control the giant African land snail, *Achatina fulica*. *Euglandina rosea* is native to the Southeastern United States, and is

able to follow the mucus trails of its prey. Although there have been experiments on food choice, it is not known if the ability of *Euglandina rosea* to follow mucus trails differs with snail pray species. This study compared the ability of *E. rosea* to follow trails of two groups of gastropods: those found within its local habitat (Southeastern USA) and those not found within its native range (Kansas). Each predator (n = 10) was tested against eight species of gastropods (four species from each area) and three individuals of each species. The results of the study indicate a high level of individual variation of predator behavior, and that gastropods from Florida and Kansas were followed at almost the same frequency by the ten predators tested.

A Survey of Aquatic and Terrestrial Gastropods in Kansas: The Nature Conservancy's Welda Prairie and the Fitch Natural History Reservation

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A preliminary survey of two areas, Welda Prairie and Fitch Natural History Reservation, were conducted in 2004 – 2005. Each area was sampled at two terrestrial sites, and one aquatic site using meter sampling grids and a general survey for larger gastropods around the sites. All sites were identified with GPS coordinates and were of different habitats to better sample the diversity of mollusks found in the small survey. The Welda site has never been previously sampled for gastropods and will be used to provide baseline data on the diversity of this Nature Conservancy site. The Fitch area was last surveyed in the 1950's and has been allowed to undergo succession. This survey will examine changes in species composition and results will be added to databases at the Kansas Biological survey. This study has been supported by two grants from the University of Kansas Field Station and Ecological Reserves.

Sex and Darts in Slugs and Snails

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In the final stages of an elaborate courtship, many slugs and snails shoot "love" darts into each other. While darts improve the reproductive success of the shooter, it is unclear why some species have darts and others do not. In fact, dart use has barely been studied except in the garden snail *Cantareus aspersus* (*Helix aspersa*). We therefore took an evolutionary approach to attempt to understand the use of darts, by investigating mating behaviour in a range of species. The prediction was that, because darts could have arisen out of an escalating cycle of sperm digestion and investment in sperm, then darts should be found in taxa that enforce simultaneous reciprocity during mating. Mating behaviour in 60 genera of land snails and slugs was recorded, and compared against dart use and a phylogeny. "Face-to-face" simultaneous reciprocal-mating behaviour is restricted to three monophyletic groups of snails and slugs, and dart-bearing species

are a subset within the same clades, which suggests a link, though not necessarily a causal one. As yet, we are unable to quantify the extent to which darts or mating behaviour are determined by common ancestry or regimes of natural or sexual selection, because the current phylogeny lacks resolution. However, the results emphasise that to understand the use of darts, then data are required from a wide range of species. The realization that several characters are correlated may stimulate further research, and could eventually lead to some testable models for dart and mating behaviour evolution.

Needs and Predictions for 21st Century Molluscan Alpha-Taxonomy

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Based on taxonomic revisions of several groups of discodorid sea slugs, such as *Discodoris*, *Peltodoris*, *Paradoris* and *Geitodoris* (Mollusca, Gastropoda, Euthyneura, Nudibranchia, Doridina), I will discuss some urgent needs in nudibranch —and more broadly molluscan— alpha-taxonomy. Some of those needs are: 1) the ending of several practices, such as naming new species based on one or very few specimens; 2) the establishment of exhaustive revisions as the standard form of taxonomic contributions, instead of brief, isolated species descriptions; 3) the use of an integrative approach to species delineation as often as possible with different kinds of data and methods, such as morphology and phylogeography (this should be mandatory in cases where morphology provides dubious results); 4) the identification of species that are hardly identifiable with morphology through other techniques, such as DNA barcoding. However, for several reasons, future taxonomic practices may not consider or answer all of those needs. I will discuss whether or not we can make predictions on what molluscan alpha-taxonomy will be in the 21st century.

Empirical Estimates of Reproductive Isolation among the Freshwater Pulmonate Snails *Physa acuta*, *P. pomilia* and *P. hendersoni*

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Physa hendersoni (Clench 1925) collected from its type locality near Yemassee, South Carolina, and *Physa pomilia* (Conrad 1834) from its type locality near Claiborne, Alabama, both display the penial morphology characterized as "type b/c" by George Te. Mate choice tests returned no evidence of premating reproductive isolation between these two populations, and no-choice breeding experiments confirmed outcross fecundity, F1 viability, and F1 fertility comparable to incross controls. Significant premating reproductive isolation does occur,

however, between the Yemassee population and *Physa acuta* from our standard Charleston population, bearing the "type c" penial morphology. No-choice breeding experiments involving Yemassee and Charleston snails returned a mixture of hybrid and selfed progeny, the hybrids proving sterile. Thus the nomen *Physa hendersoni* is a junior synonym of *P. pomilia*, while *P. pomilia* and *P. acuta* are distinct biological species.

Phylogeny and Comparative Phylogeography of West Coast Chitons

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In order to understand patterns of historic and ongoing speciation events in West Coast marine animals, we have sequenced multiple gene regions for multiple individuals of one or more populations of most shallow-water species of all 16 chiton genera occurring on the West Coast: *Leptochiton*, *Oldroydia*, *Stenoplax*, *Lepidozona*, *Callistochiton*, *Chaetopleura*, *Acanthochitona*, *Cyanoplax*, *Nuttallina*, *Schizoplax*, *Placiphorella*, *Katharina*, *Tonicella*, *Cryptochiton*, *Dendrochiton* and *Mopalia*. Chitons are well suited as models for understanding speciation in the northern Pacific. There are many species, they are relatively diverse in morphology and feeding ecology, and there have been multiple independent radiations of species. Present and previous sequence results have revealed that most of these radiations are restricted to the northern Pacific or only more recently spread to other seas such as the northern Atlantic or Arctic. If available fossil evidence is accepted at face value then the northern Pacific chiton fauna has arisen remarkably recently. Few of these species are known from even the Pliocene. The West Coast, where the chiton fauna is especially diverse, has quite homogenous environmental conditions, so it is curious how so many speciation events could have occurred in so little time. For example, we have sequenced 20 *Mopalia* spp. from the vicinity of Monterey alone. Our comparative phylogeographic analysis could reveal whether particular discontinuities along the coast correspond to pronounced genetic separation in multiple species of chitons, and thus could be in part responsible for promoting speciation in chitons as well as other similar marine animals.

Evolution of Poecilogony from Planktotrophy: Speciation in the Sea Slug Genus *Alderia*

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Variable development within a single species (poecilogony) is a rare phenomenon, and putative examples often comprise cryptic species. The sacoglossan genus *Alderia* contains a single recognized species in north Atlantic and Pacific estuaries; it is planktotrophic throughout its distribution except in California, where both planktotrophy and lecithotrophy are expressed. We present molecular, morphological and developmental data that populations south of Bodega Harbor comprise a true poecilogonous species, distinct from the strictly planktotrophic congener *A. modesta*. Northern populations (Bodega to Vancouver) consist of large adults with a smooth dorsum that produce planktotrophic larvae; those from Tomales Bay south consist of smaller adults with a raised dorsum that seasonally toggle between planktotrophy and lecithotrophy. Sequences of the mitochondrial cytochrome oxidase I gene were obtained from 204 individuals from 14 populations. Northern and southern haplotypes formed reciprocally monophyletic clades differing by 16-20%, including fixed differences at 36 of 480 sites. Molecular clock calibration indicates the species diverged in the early Pleistocene (1.4 million years ago). The northern species is absent from the south of Tomales Bay yet common only 4 km away, and was rare in San Francisco Bay until recruiting in large numbers in Feb. 2005; population dynamics may reflect differential colonization of, or adult survival on, regionally distinct strains of the host algae *Vaucheria* spp. Southern *Vaucheria* strains may limit slug body size, selecting against planktotrophy in the southern species by limiting fecundity in the face of high planktonic mortality. Molecular comparisons with Atlantic and eastern Pacific material will be discussed.

Phylogeography and Genetic Population Structure of Vermetids in Hawai'i

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Many marine organisms have a high dispersal potential especially during their larval stage. Population genetic data can be used as an indirect measure of realized larval dispersal. Studies correlating genetic differentiation with life history traits like dispersal ability have shown that, in general, high dispersal potential is associated with lack of genetic differentiation among populations. However, there are exceptions to this simple rule due to case specific biological and physical reasons. Vermetids are sessile, suspension-feeding gastropods found in shallow marine waters. They show a wide range of developmental patterns from obligate, pelagic planktotrophic larvae, which reside in the plankton for several weeks, to species with direct developing benthic juveniles, which lack a planktonic phase. The Vermetidae in Hawai'i comprise nine species. Most species are locally abundant and distributed throughout the Hawaiian Archipelago. A 569-base pair region of the mitochondrial gene cytochrome oxidase I (COI) was sequenced for the nine species from most Hawaiian Islands, including the Northwestern Hawaiian Islands. Species

with direct development show highly structured populations throughout the Hawaiian Archipelago, suggesting very limited to no dispersal among islands. Furthermore, the vermetids appear to have colonized the Hawaiian Islands via the hypothesized French Frigate Shoals-Johnston Atoll connection, with a subsequent radiation into the remainder of the Archipelago.

Preliminary Report of the Terrestrial Molluscan Fauna of the Eastern Caribbean islands, and Trinidad & Tobago

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The islands of the Eastern Caribbean, with the exception of Barbados, are part of an island arc system that stretches from Sombrero in the north to Grenada in the south. There is an inner volcanic arc of mountainous islands, and an outer arc of limestone islands, representing an older, submerged volcanic chain. The relative age, relief, geology, rainfall patterns, and forest cover on the islands have resulted in a wide variety of environments. In contrast, Trinidad and Tobago were once part of the South American continent, and share the tectonic history of northern Venezuela. All of these islands have suffered large-scale modification of their original environments as a result of colonial occupation and more recently increasing population densities. Between 2002 and 2005, twenty-one islands were visited and their malacofauna surveyed. The faunas found are quite diverse with surprising levels of endemicity on some islands, with at least sixteen endemic species on Dominica and at least one endemic on most of the other islands. Revisions of some snail groups have become necessary with a number of new species that are now being described, and some "lost" species have been re-discovered. Invasive taxa are established on many islands and are an increasingly pervasive component of their malacofauna.

Endemism, Introduced Species and Conservation in the Austral islands (French Polynesia)

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With more than 300 described endemic species, the land snail fauna of French Polynesia is of high conservation value. However, many species are extinct or threatened: 159 species from the region are recorded as extinct by the IUCN. A biodiversity inventory was done in the Austral Islands (French Polynesia), during which molluscs were sampled 70 years after the 1934 Bishop Museum's Mangarevan Expedition. Altogether, 248 taxa, 80% of which endemic, are now known from the Austral Islands, most of them being small to minute species. More than two-

thirds of the endemic species are now extinct, and alien mollusc species have appeared and are much more widespread and abundant than indigenous ones. The main reason for endemic species extinctions seems to be habitat degradation through agriculture and urbanisation, fires, introduced goats and cattle and invasive plants. *Euglandina rosea* is present only in Tubuai, where it has an impact on *Partula hyalina*, but has not yet reached the other Austral Islands. Introduced carnivorous Streptaxidae have been found in all islands, but their impact is not known, neither is the impact of other introduced invertebrates. The extreme fragmentation of native habitat, together with the very small range of many endemic species poses a further threat to their survival. Species new to science and already extinct have been discovered. All these facts makes the IUCN figure a very optimistic one, which will greatly increase when updated. Relict habitats for molluscs and other taxa have been discovered and proposed for conservation.

Ametamorphic Direct Development in *Dendrodoris behrensi* (Nudibranchia: Dendrodorididae) from the Northeast Pacific Ocean, with a Review of Developmental Mode in the family

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Dendrodoris behrensi Millen and Bertsch, 2005, has ametamorphic direct development. The embryos passed through a vestigial veliger stage lacking a shell, operculum, larval retractor muscle and pedal sensory cilia. After an embryonic period of 38 days (16-19 °C) they hatched as juveniles averaging 512 μm in dorsum length. Newly hatched juveniles possessed eyespots, rudiments of the rhinophores, and a lattice of spicules on the ventral surface of the dorsum. Only three other examples of direct development have been noted from nudibranchs from the northeast Pacific Ocean, all from the Family Dendrodorididae.

Based on a survey of the literature, mode of development was determined for 26 species and forms of dendrodoridids. Fifty percent of these taxa have planktotrophic development, 8% lecithotrophic development, and 42% direct development. Direct development is significantly more prevalent in the Dendrodorididae than reported for opisthobranchs worldwide. Three hypotheses are presented to explain this: (1) direct development is adaptive in overcoming size constraints on post-metamorphic, juvenile dendrodoridids stemming from their lack of a radula and suctorial mode of feeding on sponges. (2) Direct development is prevalent because small adult size, which is generally correlated with direct development in marine invertebrates, has been selected for in many dendrodoridids. (3) Direct development is an adaptation against high larval mortality in regions rich in dendrodoridids. Limited evidence tends to support hypotheses 2 and 3, but with some interesting developmental exceptions, not hypothesis 1.

You can Teach Old Clams New Tricks: Reconstructing Patterns and Timing of Growth – Methods and Applications

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Bivalve mollusks are biological chart recorders: their shells contain a record of the environmental conditions experienced during growth. Data is preserved in several forms, principally by periodic growth increments and geochemical variations. Combined analysis of these patterns is a powerful tool for understanding how bivalves grow, how growth reflects environmental variation, and for reconstructing evolutionary relationships among taxa.

Cross-calibration of these archives from modern specimens with observed environmental conditions reveals tight correlations with numerous physical and biological signals. Sclerochronologic archives are, however, incomplete due to the onset of senescence. Growth cessations and changing growth rates can reduce the range and resolution of the recorded environmental conditions. Nevertheless, careful analysis reveals that numerous biological and environmental signals are accurately preserved. Furthermore, shell-based environmental records are easily modeled, providing baselines against which observed profiles could be compared. Modeled profiles also elucidate which components of shell-based archives reflect actual environmental conditions versus biologically mediated growth patterns specific to the individual in question.

With a detailed understanding of an organism's growth patterns, one can address a variety of significant neontologic and paleontologic questions. Examples include, investigation of both natural and anthropogenic biogeographic shifts, documenting climate change in the past, predicting the biological responses to global warming, and reconstructing evolutionary relationships.

Systematics and Phylogeny of *Babakina* (Nudibranchia: Aeolidoidea)

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Babakina Roller, 1973 is known from the type species, *Babaina festiva* Roller, 1972 described from California and temperate Japan. *Babakina caprinsulensis* was described from a single specimen collected from northern New Zealand. Ortea (1979) described *Rioselleolis anadoni* from a single specimen from the northern coast of Spain. This species was later considered to be a species of *Babakina.* Material from the southern Iberian peninsula, the Canary Islands, the Bahamas, California, the Pacific coast of Mexico, southern Japan, Philippines, Indonesia and the Hawaiian Islands was examined in this study. The results

demonstrate that the three described species are differentiated by external and internal anatomical differences. Additionally an undescribed species was recognized from the Indo-Pacific tropical localities. Difference in the arrangement of the bursa copulatrix, receptaculum seminis and shape of the penis are consistent between distinct species. The systematic position of the *Babakina* has been the subject of some controversy. Several authors have considered it to be a member of a distinct family, while others have placed it within the Glaucidae. A preliminary phylogenetic analysis is presented to help clarify its systematic placement. *Babakina* shares plesiomorphic features with members of the Flabellinidae including the presence of two sperm storage sacs and a pleuroproctic anus, but shares apomorphies with more derived aeolids, including the presence of a single row of radular teeth.

Mating Systems and Family Conflicts in a Marine Snail

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Few groups of organisms encompass greater diversity in mating systems, parental care, and sibling interactions than gastropods. Why do females provide post-zygotic parental care in most species, males in others, and both parents in a few? Why do siblings of some species cooperate extensively, whereas others try to kill and consume each other? Are there predictable associations between patterns of parental care and the nature of interactions among siblings? How are multiway conflicts of interest among family members resolved? The mating system, because it controls patterns of relationship among family members, is one of the keys to answering such questions. *Solenosteira macrospira* is a buccinid whelk whose reproductive biology embodies multiple forms of family conflict, and, consequently, offers an exceptional opportunity to explore the constraints and opportunities for resolving such conflicts of interest. *S. macrospira* females mate multiply, and package offspring in capsules, each containing 200-300 siblings. As in other "neogastropods," there is often extensive predation on sibling eggs, zygotes, and embryos within egg capsules. Quite remarkably, female *S. macrospira* (and perhaps other closely related cantharids) oviposit almost exclusively on males (>98%), and virtually never on conspecific females or other objects. Brood carrying is risky to males, because it increases their vulnerability to predators; but, it is also essential for brood survival. In this talk, I will analyze the effects of the mating system on the evolution of male parental care and the resolution of parent-offspring and sibling conflict in this, and other, polyandrous species.

Explaining Generic Endemism in the Pacific Coast Tertiary Molluscan Faunas

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The pattern of origin and radiation of endemic genera is commonly associated with the terrestrial biotas of oceanic islands. Endemicity is relatively rare among marine genera, as even marine species tend to achieve broad geographic distribution in the relative absence of barriers to larval dispersal or migration of benthic adults. During the Eocene, molluscan faunas of the northeastern Pacific were tropical in aspect and composed of species in cosmopolitan genera. A dramatic turnover in the molluscan fauna occurred at the Eocene-Oligocene transition. This turnover is characterized by the appearance of many new genera, a rise in endemism, and the origin of the modern North Pacific cool-water fauna. What requires explanation is the number of genera in the turnover fauna that (a) remained endemic to the Northeastern Pacific, (b) became abundant elements in mid-Tertiary faunas, (c) evolved rapidly as lineages of species that have been the basis for biostratigraphic zonation and correlation, and (d) disappeared without giving rise to new taxa. The most striking examples are caenogastropods, such as the buccinoidean genera *Molopophorus* Gabb, 1864, and *Bruclarkia* Trask, 1926. Morphological analyses, taxonomic revision, and phylogenetic analyses of these and similar genera will provide both a comparative profile and a modern macroevolutionary perspective of this phenomenon.

Progress in the Conservation of Hawaiian Achatinelline Snails

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Hawai'i's ~750 species of endemic terrestrial and arboreal snails have experienced great extinction, among the most severely impacted being members of the subfamily Achatinellinae. Efforts over the last 30+ years to understand the causes of extinction, to monitor the survival of species, and to conserve what remains of this spectacular radiation (~100 spp. in 4 genera) include field-demographic studies of populations on four islands, monitoring a population of one species within a predator exclosure, captive propagation, and population-genetic studies. The O`ahu-endemic genus *Achatinella* has diminished from 41 species to about 9 at the present, 7 of them represented among the 1,500 achatinelline snails from three genera in the tree-snail laboratory. By monitoring climatic conditions in the field, we were able to establish "climates" in environmental chambers that have encouraged population-growth demographics comparable to field populations for most species. For others, species that seemingly live in almost identical field situations, laboratory propagation is far less successful. Sample data for lab populations include original (field-collected) vs. current numbers as follows: *A. fuscobasis*, 11/440; *A. decipiens*, 12/38; *A. lila*, 4/296; and *A. apexfulva*, 14/12. Molecular genetic studies have been

used to guide conservation efforts, in the field and the laboratory, for *A. mustelina*, a model that will be used for other species as well.

Larval Settlement in Response to Soluble Cues from the Benthos

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In laboratory studies, larvae of many benthic marine animals settle and metamorphose in response to dissolved chemical cues released by benthic organisms. Veligers of the nudibranch *Phestilla sibogae* were used to investigate whether such cues induce sufficiently rapid behavioral responses to bring about settlement near suitable recruitment sites, in this case their postmetamorphic prey, *Porites compressa*, an abundant coral on reefs in shallow, wave-dominated habitats in Hawai'i. Video analyses of trajectories and speeds of larvae swimming mid-water in aquaria revealed that larvae tend to cease swimming and sink in water conditioned by *P. compressa*. As cue and larvae are mixed in the turbulent flow over a coral reef, the fine-scale filamentous structure of cue concentrations in the water column translate into rapid (seconds) on/off temporal patterns of cue encountered by microscopic larvae. Larvae tethered in a miniflume and exposed to water velocities mimicking flow past freely swimming larvae were videotaped while exposed to realistic temporal patterns of cue filaments. Larvae quickly retracted the velum and ceased swimming in filaments of cue and resumed swimming when they passed out of them, actions sufficient to bring rapid settlement onto the reef. Analyses of the data derived from these studies provided a model that predicts settlement over fore- and mid-reef areas. The prediction has been tested and found to be valid.

Preliminary Phylogenetic Assessment of Invasive Apple Snails in Asia and Beyond

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The freshwater apple snail genus *Pomacea* (family Ampullariidae) has a native range covering most of South and Central America and the southeastern U.S. *Pomacea* spp. have been introduced widely in southern and eastern Asia, Hawai'i and other Pacific islands, and elsewhere in the mainland U.S. In their introduced ranges they have become major pests of wetland crops, notably rice and taro. The taxonomy of *Pomacea*, including the identity and precise geographic origins of invasive populations, is poorly understood. This lack of understanding has implications for research on many aspects of ampullariid biology, including development of effective pest management programs. As part of a systematic study focusing on the genus *Pomacea*, I am using DNA sequence data to investigate hypotheses concerning the geographic origins, molecular systematics and genetic diversity of introduced populations. So far, 300

individuals representing at least 11 putative *Pomacea* species have been analyzed. Preliminary results suggest possible cryptic species among the apple snails that have been introduced to S.E. Asia. These data also suggest multiple independent introductions of the most common invasive apple snail, *P. canaliculata*, contrary to anecdotal accounts of a single introduction spreading throughout the region. *Pomacea canaliculata* collected in Hawai'i and numerous S.E. Asian locations appears to have originated in Argentina, whereas snails from Thailand and Cambodia are likely to have come from Brazil or elsewhere and may even be a different species. Overall, the results indicate that at least four, possibly more, species of *Pomacea* have been introduced into southern and eastern Asia.

Hybridization: Lofty Theories, Taxonomic Reality

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Evolutionary theory suggests that many hybrids are less fit than their parental species and hence that hybrid populations are ephemeral, on a geological timescale. It is further commonly suggested that most Holocene hybrid zones became established merely fifteen thousand years ago.

Mollusks form a precise tool for investigating hybridization through time since the shell, which may be preserved as a fossil, is also the feature upon which species level taxonomy may be based. I exploit this combination of facts to investigate the taxonomy of Holocene *Melanopsis* of the Jordan Valley; and to explore how long ago could hybrids be traced in the fossil record of the Jordan Valley.

Holocene *Melanopsis* include two species, and the hybrids between them. Also at a 1.4 Myr old site in the Jordan Valley these same two species were found; and with them intermediates. Their low frequency and chrono-distribution suggest they are hybrids, rather than evolutionary transitions between species. These 1.4 Myr old fossils may be the earliest direct evidence of hybridization among species in nature, that is still going on today in the same region and aquatic system, among the same species. This is way beyond the "lifetime" commonly suggested for hybridization and not in agreement with classic evolutionary thought.

Geologic and Evolutionary Context of Land Snail Diversity on Oceanic Islands

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Linear, age progressive chains of basalt islands and seamounts are the geological hallmark of a long history of active intraplate volcanism as the Pacific plate has passed over discrete hotspots. Multibeam sonar seafloor mapping, records of seismic and magmatic activity, subsurface geophysical data, and geochronology reveal a repeated geologic sequence that

constrains the evolutionary life of the biota of any one island to less than 5 Ma. The geologic model for origin and evolution of island archipelagos provides a unique opportunity to investigate repeated patterns of infrequent colonization followed by intra-island speciation and evolutionary radiation. The Hawaiian and Society Island archipelagos are the best examples of hotspot chains and are also the most intensively studied, both geologically and biologically. Endemism is a pervasive pattern in land snails. Four entire families (Endodontidae, Partulidae, Amastridae, Achitenellidae) are endemic to Pacific Islands. Subfamilies and genera commonly are endemic to individual archipelagos or single islands, while species typically are confined to single islands. Six additional families (Succineidae, Pupillidae, Diplommatinidae, Helicinidae, Assimineidae, and Helicarionidae) have undergone significant Pacific island radiations. Accurate reconstructions of geologic history and phylogenetic relationships are of equal importance in explaining modern geographic distributions. Hominid-induced extinctions seriously depleted island land snail diversity before most of it could be documented. Unstudied museum collections and a largely undocumented fossil record are key to resolving major gaps in our current understanding.

Larval Dispersal and Modes of Speciation: Hypothesis Testing in *Littorina*

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Species in the marine gastropod genus *Littorina* differ in developmental mode and therefore differ greatly in dispersal potential. These differences lead to predictions about rates and modes of speciation. There is evidence for sympatric speciation by tidal height or wave exposure in some clades within *Littorina*, while in others geographic distributions support allopatric speciation. Here I test hypotheses about the mode of speciation that produced *L. scutulata* and *L. plena*, sister species with wide-dispersing, planktotrophic larvae. Simulation modeling of larval dispersal and ocean currents suggests plausible mechanisms for geographic isolation and allopatric speciation. Relevant to other models of sympatric speciation in the genus, data on the species' relative distributions at both large (among-shore) and small (within-shore) scales along the Pacific coast of North America provide estimates of the habitat separation of precursor morphs in the common ancestor, allowing analysis of reproductive isolation and divergent selection. With the current overlap of distributions at all scales, sympatric speciation seems likely only if divergent selection at the time of speciation has since relaxed, allowing the species to re-invade overlapping niches. Given estimates of the time since speciation and possible mechanisms of isolation, allopatric speciation followed by range expansion better explains the available data.

Evolutionary Patterns in Pacific Amber Snails (Succineidae): the Relative Roles of Vicariance and Dispersal in Diversification and Island Biogeography

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Our work applies a molecular approach to investigate origins and patterns of biological diversity in endemic Pacific land snails. In this study we seek to understand patterns of dispersal and diversification in Pacific succineid snails, focusing on the diverse Hawaiian assemblage. Preliminary results inferred from mitochondrial (COI, 16S) and nuclear (H3) markers suggest 1) a complex colonization history in Hawai'i, including multiple primary colonization events from non-Hawaiian sources; 2) examples of adherence to as well as violation of the progression rule pattern of colonization from older to younger Hawaiian Islands; 3) evidence of colonization by an endemic Hawaiian lineage into the South Pacific; and 4) unexpected patterns of inter-island relationships. Many Pacific islands, including the Hawaiian archipelago, arose in situ as the Pacific plate moves over a stationary hot spot. Thus, while local vicariant events within island chains, such as fragmentation of large "super islands" into smaller ones by emergence and submergence of land bridges resulting from the dynamic processes of formation, subsidence, and erosion of islands as they move away from the hot spot, all play important short-term roles in lineage isolation, dispersal is a key process in diversification of Pacific island succineid land snails over the long-term. Molecular evidence suggests that long-distance oceanic dispersal and colonization of the Hawaiian Islands has been rare but important, whereas inter-island dispersal has been far more common, but has not always resulted in lineage splitting. Our results demonstrate that oceanic dispersal should not be viewed as a trivial biogeographical phenomenon and suggest that its importance has been underestimated.

What Can "Stems, Loops and Lollipops" Tell Us about Basommatophora?

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The Basommatophora is comprised of a conchologically, anatomically, and ecologically heterogeneous assemblage of pulmonate gastropods. The monophyly of Basommatophora has long been doubted and this view is substantiated indirectly by the markedly different classification schemes and composition of the group presented by different systematists. The presumed high degree of phylogenetic differentation among the taxa and the antiquity of the group makes discovery of unambiguous homologous characters to infer phylogenetic relationships difficult at best. The objective of this study was to test the monophyly of Basommatophora and provide a preliminary hypothesis on the phylogenetic relationships of the group using highly conservative cytoplasmic nuclear LSU ribosomal gene sequence

Historic Pacific Grove Intertidal Nudibranch Collections are a Baseline with which to Test Climate-related Species Range Change Hypotheses

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Recent studies, using historic surveys as baselines, have found pole-ward shifts in species' ranges that correspond to increased air and/or sea temperatures. Most of these studies use observational data: annual butterfly counts, biological "inventories" and biodiversity monitoring studies. These data are invaluable, but in most cases specimens were not collected, therefore exactly what was seen can never be known. Although museum data has been referenced in some of these studies and has been integral in documenting other recent community changes, such as the timing of biological invasions, it is often discounted as baseline data. Museum specimens are not always collected in a comprehensive, repeatable manner and common organisms are not collected as often as rare organisms. Frank MacFarland studied the nudibranch fauna of Monterey from 1901-1951. His notes, drawings and specimens are now part of the California Academy of Sciences archives and collections. I am interested specifically in the genus *Cadlina.* There are four species of *Cadlina* with overlapping ranges in the Monterey Bay Region and over eighty specimens of *Cadlina* collected by MacFarland from Pacific Grove are in our collection. This data set is comprehensive and repeatable and allows unique comparison with new collections made following MacFarland's notes. I will examine the morphology and sequence mitochondrial DNA of MacFarland's specimens and newly collected specimens from the same localities. I will examine both collections to explore any changes in species' distributions in Monterey Bay. I will use the historic collection and new collections as populations in a larger phylogeographic study.

Historical Phylogeny of Tahitian *Partula*

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Oceanic islands hold particular interest for both evolutionary and conservation biologists. Native plants and animals evolved in isolation on these islands and provide detailed insights into fundamental evolutionary processes. However, they characteristically lack well-developed defensive mechanisms and are exceptionally vulnerable to introduced predators. Using DNA analyses of museum specimens, we aim to reconstruct the evolutionary history of a critically threatened radiation of land snails from Tahiti (French Polynesia). This Pacific island snail fauna has recently been driven to the brink of extinction by an introduced predatory land snail. Our

museum samples predate the introduction of the predator and, in their DNA, they collectively contain a genealogical record that we can use to revise the traditional shell-based taxonomy and to determine how all these snails evolved on such a small, geologically young, island. Our research will have practical value in helping to prioritize on-going conservation and rehabilitation efforts. Collaborative agreements have been established with Zoological Society of London personnel involved in overseeing captive Tahitian snail zoo populations and in saving the last remnant wild populations. Our shared aim is to place the remnant wild and captive populations into their proper evolutionary context: that of the previously intact fauna, by obtaining DNA profiles of extant wild and captive populations that will be referenced with our historical Tahitian database.

Species-level Phylogeny and Phylogeography of *Conus*: a Progress Report

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Segments of two mitochondrial genes (16S rRNA and COI) of about 150 species of *Conus,* or more than 25% of the recognized species in the genus, have now been sequenced. We use these data to explore the degree of agreement between species distinguished by morphological and molecular criteria, and to test prior hypotheses of species-level phylogeny and phylogeography based on analyses of smaller samples. For *Conus* of the Indo-West Pacific region, 16S genetic distances of species recognized on shell morphology generally confirm the prior taxonomic decisions. Increased molecular sampling continues to support the early (probably Late Eocene-Early Oligocene) divergence of two major lineages. The smaller of these, thus far comprising only 16 species, is predominantly distributed in the Eastern Pacific and Western Atlantic regions. The larger major clade, comprising all remaining species, is predominantly Indo-West Pacific but includes representatives of all other geographic regions. Recent analyses emphasizing Western Atlantic species suggest two subsequent radiations, probably during the Miocene. One of these contains 12 Western Atlantic and 3 Eastern Pacific species; the other, 2 Western Atlantic, one amphiatlantic, 5 Eastern Pacific, and a single Indo-West Pacific species. The new results also support our prior hypotheses of monophyly of molluscivorous *Conus* species and polyphyly of piscivorous species.

Frustrated Virgins and Reproductive Flexibility in the Sacoglossan Sea Slug *Alderia*: How Hypodermic Insemination Affects Selfing and Speciation

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Sacoglossan sea slugs live and feed on species-specific host algae, and their planktonic larvae metamorphose in response to host-produced cues. Coevolution between slugs in the genus *Alderia* and their host algae *Vaucheria* spp. has produced complex dispersal strategies and cryptic speciation in Californian populations. I will discuss how hypodermic insemination leads to self-fertilization and inappropriate sex between species. The southern *Alderia* sp. displays a rare reproductive polymorphism, producing long-lived planktotrophic larvae or short-lived lecithotrophic larvae. Virgin slugs, metamorphosed and reared in isolation, produced unfertilized egg masses 5 days after reaching reproductive maturity; unfertilized clutches were significantly larger than fertilized clutches of paired control slugs, suggesting mating costs normally reduce fecundity. Virgin slugs began self-fertilizing 5 days after initial egg production, a phenomenon only reported for 2 other opisthobranchs, both sacoglossans. Planktotrophic virgins lowered their fecundity to control levels after selfing, whereas lecithotrophic virgins produced more eggs per clutch whether unfertilized or self-fertilized, compared to mated controls. Development mode and sexual history therefore interactively affect energy allocated to reproduction. Selfing via accidental auto-injection may be a common consequence of hypodermic insemination that has gone unnoticed due to sperm storage abilities of sacoglossans. The sibling species of *Alderia* overlap without hybridizing, and cross-inseminations in the lab normally yield no offspring, suggesting post-zygotic isolation has arisen. Hypodermic insemination precludes most forms of pre-zygotic isolation seen in other organisms; I therefore propose that in sacoglossans, sister species will occupy different algae in sympatry, achieving reproductive isolation pleiotropically as a by-product of host choice behavior.

Mediterranean Land Snails and Wildfires

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Wildfires in Mediterranean scrub in Israel occur mainly during the hot, dry summer, when land snails are aestivating. Three common Mediterranean species were investigated following a wildfire (in the Judean Hills, Israel). *Euchondrus septemdentatus* (inhabits shallow soil pockets) was completely eradicated by the fire and has not re-colonized burnt areas to this day (7 years post-fire). *Levantina hierosolyma* and *Buliminus labrosus* (crevice-dwellers) survived the fire; their population dynamics were studied for five years in post-fire conditions. Age composition differed between burnt and control plots in *L. hierosolyma* but not in *B.*

labrosus. In the laboratory *L. hierosolyma* was found to be well adapted to the dry conditions prevalent following wildfires. Its normothermic water loss rate (only 5% in 21 days) is the lowest ever recorded for a Mediterranean land snail. When *L. hierosolyma* was exposed to combinations of high temperatures (50-100^{0}C) and time periods (5-120 minutes) in the laboratory it survived exposures of up to 20 minutes at 60^{0}C (14% survival) and 5 minutes at 75^{0}C (100%). Longer exposures at 75^{0}C or higher temperatures (100^{0}C) resulted in 100% mortality. Of the three species, *B. labrosus* seems to be the least affected both by fire and post-fire conditions. *L. hierosolyma* populations are affected by the fire, but laboratory results suggest they are at an advantage in the dry conditions prevailing in the wake of wildfires. *E. septemdentatus* does not survive and does not re-colonize burnt areas, even when reintroduced, indicating it is unable to adapt to post-fire conditions.

Predator-prey Dynamics of Late Paleozoic Ecosystems: A Case Study on the Role of Molluscs

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Predation plays a major role in modern molluscan ecology but knowledge of the origins of molluscan predator-prey dynamics in deep time remains limited. The majority of Early Paleozoic gastropods and bivalves were restricted to nearshore habitats but during the Carboniferous both classes radiated into "normal" marine systems, at which time molluscs were exposed to a greater risk of predation. Previously, predators primarily attacked brachiopods. How did the molluscan invasion of these ecosystems affect predator-prey dynamics and did molluscs respond to this increase in predation? We examine several exceptionally well-preserved assemblages from the Late Carboniferous of Texas that include diverse gastropods, bivalves, and brachiopods, especially pleurotomariniid gastropods; mobile, shallow-infaunal, bivalves; and productide brachiopods. Most taxa are similar in size and shell thickness, so predators might be expected to prefer fleshier molluscs over brachiopods. Drilling predation was restricted entirely to sedentary, epifaunal taxa, regardless of taxonomic affinity; these drillers apparently were not as adept as some Holocene drillers at capturing mobile prey. Crushing predators, however, left scars on gastropods (18% of specimens) much more frequently than bivalves or brachiopods (8% each; difference is significant: chi-square test, $p < 0.01$). This difference is either due to a greater rate of attacks on gastropods or greater success against other taxa. Bivalve crushing frequency may be low because most bivalves were infaunal. The higher frequency of scars on gastropods suggests that an increase in ornament in many gastropods lineages, including the abundant pleurotomariniids, during the Late Carboniferous, may have been an adaptive response to predation.

Sexual Selection and Mating Systems in the Genus *Ariolimax* (Stylommatophora: Gastropoda)

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It has been hypothesized that where genital characters are taxonomically important at the species level, sexual selection has been important. The taxonomy of the genus *Ariolimax*, the banana slugs of North America, has been based on genital characters. Behavioral and morphological studies of *Ariolimax* spp. provide substantial evidence for sexual selection. Morphological studies show a previously undescribed genital polymorphism in *Ariolimax buttoni.* Aphallate individuals of this species were previously termed *Aphallarion buttoni* whereas euphallate forms had been synonymized with *A. columbianus.* This phally polymorphism would reduce the number of individuals capable of mating as males in populations of *A. buttoni*, thereby producing a skewed sex ratio. Behavioral data show that all three species of the *Meadarion* subgenus (*A. californicus, A. brachyphallus* and *A. dolichophallus)*, share a lengthy courtship behavior. *A. brachyphallus* may also show penial stroking. *A. stramineus* of the subgenus *Ariolimax* has a very different courtship behavior involving brief (20 m) mutual exploration with early penis eversion. Apophallation has been observed in *A. californicus and A. dolichophallus.* Mating encounters involve a single 2h simultaneously reciprocal intromission in *A. dolichophallus;* bouts of brief unilateral intromissions in *A. californicus and A. brachyphallus;* a 2h simultaneously reciprocal intromission preceeded by a brief unilateral intromission in *A. stramineus* and a > 24 h reciprocal intromission in *A. buttoni.* Phally polymorphism, apophallation, lengthy and elaborate courtship and the patterns of reciprocity observed provide circumstantial evidence for sexual selection in this genus.

Hemocyanin and Molluscan Phylogeny: Outcomes, Restrictions and Perspectives

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The phylogeny of the Mollusca is still debated at all systematic levels. It is therefore justified to include as many useful phylogenetic characters as possible. We found that the blue respiratory protein hemocyanin has some potential in this regard. Molluscan hemocyanin subunits possess an evolutionary rate of ca. 10^{-9}, have a molecular mass of up to 400 kDa and are encoded by up to 10,000 bp, thereby providing a statistically sound data set to trace molluscan phylogeny. According to molecular clock calculations, this protein originated *ca.* 740 million years ago, in the late Precambriam. After the separation of the molluscan classes, it was apparently lost in the Caudofoveata, Scaphopoda and most bivalves, but retained in the

Polyplacophora, Gastropoda and Cephalopoda, and also in the protobranch bivalves. We found that phylogenetic trees reconstructed from hemocyanin sequences are of only limited use to unravel relationships between these four classes, but most efficient to trace phylogenies within the latter. Examples for successful analyses range from the supraorder level via the family level down to the genus level. In addition to sequence alignments, differences in gene architecture and quaternary structure of this protein provide clues to elucidate key events of molluscan phylogeny.

A Combined Analysis of the Phylogeny of Cephalopoda

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This study provides a comprehensive phylogenetic analysis of Cephalopoda using molecular and morphological data. Regions of four molecular loci (nuclear 18S rRNA, 28S rRNA, histone H3, and mitochondrial cytochrome *c* oxidase subunit I) were combined with 101 morphological characters to test interfamilial relationships of sixty cephalopod taxa, with emphasis on the families within Decabrachia ("squids," cuttles and their allies). Individual molecular and combined data sets were analyzed using the direct optimization method (with parsimony as the optimality criterion) and partitioned Bayesian methods. Monophyly of Cephalopoda, Nautiloidea, Neocoleoidea (all extant cephalopods except nautiluses) and Decabrachia was supported by most analyses; however, monophyly of Octobrachia (octopuses) was falsified due to a lack of support for Cirroctopoda + Octopoda in some trees. Vampyromorpha (vampire squids) was found to be sister to Decabrachia (rather than Octobrachia) in both combined molecular and total evidence analyses. Within Decabrachia, support was found for a relationship between the sepioid orders Idiosepiida, Sepiida (true cuttles), Sepiolida and the teuthid family Loliginidae, rendering the order Teuthida polyphyletic. We believe that the rooting of the neocoleoid portion of the tree, the phylogenetic position of Vampyromorpha and the possible paraphyly of Octobrachia merit further investigation.

Extinction and the Evolutionary History of Late Cretaceous and Early Cenozoic Veneroid bivalves

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Although the causes of mass extinctions in the fossil record have been studied in detail, recoveries have received little attention until recently. This study focuses on the effects of two extinction events, the end-Cretaceous (K/T) and end-Eocene (E/O), on long-term patterns of

morphology and ecology in veneroid bivalves. Systematic and stratigraphic data were collected for 140 subgenera of veneroids from the Late Cretaceous through Oligocene of North America and Europe. Morphological data were collected for 1236 specimens representing 101 subgenera. Extinction selectivity and preferential recovery were assessed with respect to morphology, and by extension, burrowing ecology in these bivalves. Veneroids underwent a substantial extinction at the K/T boundary, although diversity recovered to pre-extinction levels by the early Eocene. Despite the severity of the K/T extinction, I found little evidence of morphological or ecological selectivity. In contrast, the K/T rebound was significantly biased towards smaller taxa with more elliptical shells and relatively deeper pallial sinuses (i.e., towards relatively deeper, faster burrowers). The E/O event was considerably smaller and the recovery interval biased towards larger veneroids. It is clear that the K/T, although short-lived in geological time, exerts a stronger influence on diversity, morphology, and ecology in veneroids than the E/O event. The morphological and ecological effects of the K/T are not tied to the extinction itself, but to the recovery that follows. The K/T recovery initiates a trend towards deeper burrowing that helps to establish veneroids as one of the most abundant and successful groups of modern marine bivalves.

Dichostasiidae Yochelson, 1956, Permian to Holocene, Defined on Opercular and Shell Characters (Vetigastropoda: Trochoidea)

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The family Dichostasiidae (based on the Permian genus *Dichostasia* Yochelson, 1956; shell diameter 5 mm) has a circular aperture and fine lamellar sculpture, which led me to place the genus among the living Liotiidae in 1981. The family Liotiidae is characterized by a circular aperture and an operculum with a multispiral arrangement of calcareous beads on the outer surface. Such opercula are not amenable to fossilization, which makes the early record of Liotiidae open to question. Here I report on the operculum of a new living genus from the Indo-Pacific sublittoral (no preserved bodies, maximum shell dimension 5 mm) with lamellar sculpture that had initially suggested affinity to Liotiidae. That assignment is ruled out because three shell specimens are known that have wedged-in, solid calcareous opercula. This operculum has the inner surface conical with a fine multispiral pattern, and the outer surface with radial rugosities and a deep central pit. A similar operculum has been described for the well-known and broadly distributed Mesozoic genus *Metriomphalus* Cossmann, 1916. *Metriomphalus* has previously been tentatively placed in the basal turbiniform family Colloniidae, but it has coarse lamellar sculpture (instead of the dominant spiral sculpture of Colloniidae). Colloniidae differ in having the peristome interrupted and the operculum becoming paucispiral on the inner surface of the final volution. Details of the morphology of the mature lip of the new living genus closely resemble those of the Permian genus *Dichostasia*. My hypothesis is that these three genera (the new genus, *Dichostasia*, and *Metriomphalus*) and certain other Mesozoic genera, for which the operculum is yet unknown, can now be tentatively assigned to Dichostasiidae. The true Liotiidae have details of shell sculpture that support a first appearance in the Late Cretaceous. There are

now three basal turbiniform families (Liotiidae, Colloniidae, Dichostasiidae), defined on opercular and shell characters. Two of these families, the Liotiidae and Colloniidae, have a similar rhipidoglossate radula (inner marginal teeth not enlarged), which can now be considered to be plesiomorphic in the basal turbiniform families. The radula of Dichostasiidae as here defined is unknown, but is probably of the plesiomorphic type.

Elemental Fingerprinting to Determine Larval Dispersal: An Example Using Mytilid Mussels

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Due to the small size of typical planktonic larvae, tracking larval movement has been a difficult, if not impossible, task. Questions about larval transport focus largely on where larvae go (dispersal) and where larvae come from (connectivity). To answer these questions, studies addressing dispersal have included direct observations, mark-recapture experiments with tags and dyes; while studies addressing connectivity have included physical modeling and elemental tags. Technological advances have facilitated the use of elemental fingerprinting analysis to evaluate origins and trajectories of some planktonic larvae. Spatial variability in trace elemental characteristics of different coastal water masses is recorded in the geochemistry of biogenic carbonates (e.g., otoliths, statoliths, shells). Since shells are deposited throughout planktonic larval growth, they effectively record the environmental characteristics of different water masses or habitats occupied by larvae during development. We are using trace element fingerprinting methods to evaluate the spatial scale and strength of connectivity among *Mytilus galloprovincialis* and *M. californianus* populations in southern California. Our approach involves laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) to resolve variation in larval shell chemistry that reflects recruit origins and temporal patterns of larval transport. We are also testing realized population connectivity determined from trace elemental analysis of recruit origins against *a priori* predictions based on circulation and metapopulation models. The information obtained regarding source populations and connectivity will increase our understanding of larval transport and retention as well as marine metapopulation dynamics, ultimately aiding in the conservation of coastal resources and design of marine protected areas.

Evolution of Anatomy and Morphology in Miniaturized Marine Snails (Neogastropoda: Columbellidae)

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The evolution of small body size has important consequences for organismal ecology and physiology, and may be associated with the episodes of origination and diversification that have led to many higher taxa. Preliminary research indicates that several investigated species of small Indo-Pacific columbellid marine snails are miniaturized; they are similar in gross anatomy to much larger species but have proportionately smaller cell sizes. One question remaining to be addressed is what anatomical and morphological changes have occurred in addition to miniaturization that might be associated with the transition to small size. Anatomical reduction is commonly seen in small-bodied species, and may be an important prerequisite for the origin of novel body plans. In this ongoing study, anatomical data corroborated with species level phylogenetic hypotheses indicate that miniaturized columbellids are in some respects anatomically simplified in addition to being miniaturized; they lack opercula, the osphradium is monopectinate rather than bipectinate, and certain conchological characteristics are reduced in size. These characteristics are not restricted to the smallest species however, and may be associated with factors other than size reduction.

Do More Tissues Automatically Equate to a Heavier Breather?

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The fissurellids (Mollusca: Vetigastropoda) are bilaterally symmetrical. They are commonly known as keyhole or slit limpets due to a hole or slit either at the apex or anterior margin. The mantle cavity of fissurellids contains paired ctenidia, osphradia and hypobranchial glands. Interestingly, the fissurellids are the only gastropods in which all mantle cavity organs are paired and symmetrical. Like most vetigastropods, fissurellids also have paired auricles, gonads, kidneys and the digestive tract and nervous system are crossed. Symmetrically paired organs are not found in any of the other groups of uncoiled limpet-shaped gastropods. Even the sister group to the gastropods, patellogastropods (true limpets), have asymmetrical organs with highly modified mantle cavity arrangements. Not only is the plesiomorphic mantle cavity arrangement in fissurellids unusual for gastropods, there is also a great size variance within the group, with the larger species having extended mantle and foot tissue. Despite the increase in surface area of tissue a deepening of the mantle cavity has not occurred. As a result of this the paired ctenidia do not appear to have enlarged and the question of how these animals are reaching their required oxygen quota arises. This research aims to test hypotheses about the

popularly perceived notions regarding the inefficient nature of a symmetrical mantle cavity and to determine if the foot or mantle are being utilised as secondary respiratory surfaces.

Changes in the Mussel Community of Ohio Brush Creek

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We evaluated the status of the mussel community of Ohio Brush Creek and its tributaries in southeastern Ohio over a 17 year period. This stream has harbored one of the most diverse mussel communities in the region, with 39 of the 76 species recorded for the entire state of Ohio. Species richness increased to 23 in 2004, from 16 and 20 species found in 1996 and 1987, respectively. Despite the increase in species number, the abundance of live and freshly dead shells declined, particularly for abundant species. Community structure has changed from one dominated by a few abundant species to a more evenly distributed community composed of a greater number of species with lower abundances. More detailed study of the mussel community of Ohio Brush Creek is warranted. Ongoing mark-recapture work combined with size class structure will provide information to assess whether changes in abundance are due to adult survivorship, recruitment, or are simply a reflection of variability in population size and sampling. In addition, analysis of the health of fish host populations and mapping of substratum types available to mussels will allow ascertaining potential factors affecting the mussel community. At this time, large scale factors, rather than localized disturbance appear to be responsible for the observed changes in diversity and abundance of mussels.

Mating and Egg-laying Behavior in *Aplysia*: Pheromones and Neural Mechanisms

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In the marine mollusk, *Aplysia californica*, there is a sequence of behaviors that occurs during mating and egg laying that lasts for up to several hours. Pheromones appear to play a critical role in initiating and coordinating the behaviors between individuals. Within each individual, the behavioral sequence is initiated by a chemical stimulus – probably a contact pheromone – located in an egg mass laid by others. In the central nervous system, this stimulus triggers release of neuropeptides from a defined group of neuroendocrine cells and other neurons coupled to them. The actions of the neuropeptides within the central nervous system and on peripheral organs serve to orchestrate the behavioral sequence, which in these hermaphrodites consists of mating as a female, laying eggs, and then mating as a male.

The release of neuropeptides corresponds to what ethologists long ago speculated to be an "innate releasing mechanism." The innate releasing mechanism is triggered by a sign

stimulus – in this case a contact pheromone in the egg mass. Many features of the reproductive behavior of *Aplysia* are also features of instinctive, reproductive behavior in other mollusks and other animals, including humans. In many of these cases it seems likely that there is an innate releasing mechanism that also involves the release of neuropeptides from defined neural circuits. The neuropeptides act on target neurons within the central nervous system to modulate electrical signaling for minutes or hours, and thus regulate aspects of the behavior.

Interpreting Life's History Through the Lens of the Present: Accounting for Variability in Biogeographic Inference

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Phylogenies and distributions of extant species are often used to test competing historical biogeographic scenarios and elucidate diversification processes. As such, inferences are only as good as the robustness of the trees and the accuracy of the ranges. What is more, both datasets are inherently problematic because of their temporal variability: phylogenies based on sequence data must account for coalescent processes and thoroughness of sampling, while biogeographic ranges are dynamic with range expansions via dispersal and contractions leading to relictualism and ultimately extinction. When interpreting historical events from present perspectives, we must be certain to check assumptions, accommodate this variation, and have a clear understanding of null hypotheses. Should we expect sister pairs to behave equally on the same evolutionary stage if they have equivalent attributes? How much can variability affect resulting patterns? Given a well-supported phylogeny and good range data, how many alternative biogeographic scenarios are possible? Are probable? How do we take account of the coalescent process in polarizing biogeographic events? Are conclusions vulnerable based on incomplete sampling? What additional information can increase confidence in explanations? I will address each of these points using data from various molluscan groups including cowries, cones, limpets, and turbinids.

Mexican Holospirinae in Review (Gastropoda: Urocoptidae)

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The subfamily Holospirinae range from the southwestern states of Arizona, New Mexico and Texas to southern Mexico. Within the area of Puebla and immediately adjacent states, 28 species are recognized of which 14 are new. Twelve species groups of *Holospira* are recognized within the subgenus *Holospira* within the study area. Within the subgenus *Stalactella*, five species are recognized. The genus *Holospira* is much more widespread then *Stalactella* which is

confined to Puebla and Oaxaca. They are found in submesic and xeric habitats of limestone or dolomite substrata. Colonies of snails are limited to proximal outcrops. Prior literature poorly described morphological features for species identification. This study uses shell morphology including internal lamellae, radula, and soft anatomy to differentiate between species-groups. The internal lamellae serve as a predator barrier and characterize each group. They are represented typically by four lamellae: basal, columellar, palatal and parietal. Some species-groups like *H. melea, H. hogeana, H. fortisculpta, H. scololaema* and *H. haploplax* have a reduced number of lamellae. The species-groups that have the characteristic four internal lamellae vary greatly in shape between them. The four lamellae stage is considered to be the ancestral condition and evolution of some groups occurred through loss of lamellae. This statement is based on the oldest known fossil of *Holospira* as well as the general occurrence of four lamellae throughout the range of the genus.

Two New Northeastern Pacific Nudibranchs

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The northern Pacific coast of North America continues to reveal new species of nudibranchs in the subtidal zone. A deep-water dredge off the coast of Washington state brought up a new dorid from a depth of 146 m. It was photographed live and obligingly laid an egg mass. Internal investigation revealed it was a new species of the uncommon genus *Baptodoris* (Family Doridiidae). The internal anatomy with SEM's of the reproductive spines is shown.

The cold winter fjord waters of British Columbia revealed to divers a new species of *Janolus* (Family Zephyrinidae) crawling on the muddy bottoms. Although this species has been photographed and collected a number of times, its spawn and food remain unknown. The anatomy of this species is shown with special emphasis on their elaborate jaws designed to nip bryozoans. The systematic relationships of these two new species are discussed.

Pondering the Purpose of Precarious Postures: The Effect of Littorine Snail Shell Orientation on Body Temperature

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Littorine snails living high in the intertidal zone must endure some of the longest aerial exposures and hottest temperatures of any marine organism. During periods of calm sea conditions a snail may be out of the water for days on end. The high temperatures and prolonged periods of desiccation experienced by these snails could lead to physiological stress or death. On the west coast of North America, several of the *Littorina* species have been observed to carry out a unique behavior under particularly stressful circumstances. Snails will glue the lip of the shell

to the rock substrate and lift the rest of the shell away from the rock. This leaves the entire snail perched on the lip of shell, which minimizes conduction of heat from the hot rocks and maximizes convective cooling with the surrounding air. Shells of four species of northeastern Pacific *Littorina* were used to create models to measure shell temperatures under hot conditions in the lab and in the field. When littorine shells are perched on the lip of the shell, the shell temperature can stay 2 to 5 degrees C cooler than the same shell sitting down on the rock. These lower shell temperatures may be important for minimizing the intensity and duration of heat stress, as well as lowering the rate of evaporation. The benefits and potential liabilities of this behavior will be discussed.

Sexual Conflict and the Rise of Alternative Reproductive Tactics in the Banana Slug, *Ariolimax dolichophallus*

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Banana slugs of the genus *Ariolimax* are simultaneous hermaphrodites, like all pulmonate slugs. They are unusual, however, in that sometimes after mating one slug will chew the penis off of its mating partner. This bizarre behavior, termed apophallation, is often reciprocal, where both slugs lose a penis at the end of the mating encounter. The penis does not grow back. In the past, the main explanation for this behavior was that it was a maladaptive consequence of selection favoring a large penis. Here I report high frequencies of aphallate slugs in the field, which suggest a potential for strong selective pressure caused by apophallation, making non-adaptive hypotheses unlikely. I also introduce a game theoretical approach for examining apophallation and the potential invasion of alternative behavioral strategies, with evidence from lab reared animals.

Quantitative and Qualitative Variation of the Protein Content of the Embryos of *Crepidula navicula* (Caenogastropoda: Calyptraeidae) During Intracapsular Development

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Hatching size and mode determine in great measure the chance of survival in young caenogastropods. These are determined by the energy available during embryonic development, which is related to the amount and type of proteins in the embryo. Egg capsules of *Crepidula navicula* contain 1-6 eggs, all of which develop to the hatching stage as pediveligers, although, cannibalism among sibling embryos has been observed. To determine how the proteins are being used by the embryo during development as well as if there is a significant increase of their

protein content confirming the importance of cannibalism, we determined the protein content of the developing embryos of *C. navicula* at 9 diferent stages of development as well as the electrophoretic pattern of the proteins at these same stages. We found 4.83±0.54 µg protein/egg, a value that decreases significantly to the trochophore stage to 2.63±0.66 µg, increases to the veliger I stage to 5.62±0.75 µg/veliger and then decreases at the hatching stage to 3.71±0.74 µg/hatchling (Kruskal Wallis followed by Tukey multiple comparisons, $p<0.001$).

The electrophoretic pattern showed that eggs and embryos are characterized mostly by high molecular weight proteins (88-150 KDa), two of 16 and 18 KDa respectively and some minoritarian proteins of 44 and 53 KDa. At hatching, most of these proteins have been consumed and transformed into lower molecular weight proteins, and many minoritarian bands above 70 KDa were observed in pediveligers and at the prehatching stage.

Mapping Marine Invertebrate Biodiversity Hotspots in the Indo-Pacific Ocean Using GIS

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Under the auspices of the MacArthur Foundation, the Pacific Biological Survey, Bishop Museum studied the distribution of marine invertebrates in the Indo-Pacific as an aid to set policies and priorities for conservation of marine organisms. The taxonomic coverage included all 794 hermatypic coral species, 1,166 mollusks, and 289 crustaceans, totaling 2,249 species in the Indo-Pacific. Distributional data were gathered from museum collections and taxonomic literature and georeferenced to plot species distributions on maps using ESRI ArcGIS 8.3. Composite maps of biodiversity for each family revealed patterns of species richness that were concordant with a few exceptions. The region between the Philippines, the Malay Peninsula and New Guinea has the highest diversity of corals and is known as the "coral triangle." From this center of diversity in the tropics there are latitudinal and longitudinal gradients, decreasing rapidly with distance from the center. Mollusks and crustaceans studied showed similar patterns of diversity, although the region of highest diversity was slightly wider than the coral triangle. Data on threats to coral reefs were used to rank the biodiversity hotspots according to species richness and threat risk, to preserve the largest number of species concentrated in small areas. The top biodiversity hotspots are: coral triangle, Vietnam, Thailand, Micronesia, Fiji, Okinawa, Sri Lanka, Seychelles, Madagascar, Comoro and Mascarene Islands, Tanzania, and Red Sea, among others. Many of these areas were recently affected by strong earthquakes and tsunamis, and biodiversity may be under greater danger than previously reported.

Biodiversity of Marine Molluscs of the Gulf of Mexico

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The Harte Research Institute for Gulf of Mexico Studies at Texas A&M University-Corpus Christi is sponsoring a 50-year update of "Bulletin 89." This volume, *Gulf of Mexico-Its Origin, Waters, and Marine Life*, on the state-of-the-science in the Gulf of Mexico (GOM), published in 1954, is still used as a major historical reference for the region. The updated version will be published in 2006 in five volumes, with one volume dedicated to the Biota of the GOM. A team of more than 100 expert taxonomists from six countries (including Cuba, Mexico and the USA) was assembled to compile the biodiversity of the GOM. This endeavor represents the largest in-depth taxonomic treatment of the whole biota of a large marine ecosystem of this scale. The current known diversity of molluscs alone is almost the same as the known biota of the region 50 years ago, with about 2,700 molluscan species documented in the GOM. Although still preliminary, the diversity of molluscs in the GOM can be broken down as follows: Aplacophora-13 species (with seven new species being described); Polyplacophora-39 species; Gastropoda-circa 1,900 species; Cephalopoda-24 species; Bivalvia-circa 670 species; and Scaphopoda-41 species. New records (range extensions), recent descriptions of new species and the inclusion of micromolluscs and deep-water species account for the sharp increase in the known diversity in the region.

Identification of Host Specific Genes in a Sepiolid Squid/*Vibrio* Mutualism

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Bioluminescent bacteria from the genus *Vibrio* exist in a diverse number of environmental habitats. They can be found as saprophytes, symbionts of leiognathid fishes and sepiolid squids, or free-living in natural seawater. The mutualistic associations between *V. fischeri* and the sepiolid squids *Euprymna tasmanica* and *E. scolopes* (squids endemic to Australia and the Hawaiian archipelago, respectively) are host specific, with *V. fischeri* strains highly adapted to squids found within their same habitat. While the development and maintenance of this mutualism has been well studied from the host's perspective, *V. fischeri* gene expression within the light organ has not been characterized. To determine this, I have produced libraries of *V. fischeri* genes expressed exclusively in the host light organ or in seawater using Selective Capture of Transcribed Sequences (SCOTS), a procedure that relies on a series of normalization and enrichment hybridizations to identify differentially expressed genes. Genes expressed in the light organ include multiple chaperones, fermentation enzymes, amino acid uptake and biosynthesis proteins, pH homeostasis, and adhesion. Seawater-expressed genes include those for biosynthesis of a number of compounds, aerobic respiration, and multiple ion

channel pumps. Comparisons of these data support the notion that the light organ is an anoxic environment in which host-derived nutrients are supplied to *V. fischeri*. To my knowledge, this is the first time bacterial gene expression has been examined between two natural environments in an environmentally transmitted mollusc/bacterial symbiosis.

Using Nested Clade Analyses for Determining Species Boundaries in Three Indo-West Pacific *Euprymna* Species and their Luminescent Symbionts

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The sepiolid squid-*Vibrio* mutualism is an excellent system for examining mechanisms of cospeciation and host tracking patterns among a wide variety of symbiotic squid species. Currently, I am using genetic diversity and nested clade analyses to examine the variation between three allopatric *Euprymna* squid species: *Euprymna scolopes* (Hawai'i), *E. hyllebergi* (Thailand), and *E. tasmanica* (Australia). Using three mitochondrial loci (cytochrome *c* oxidase subunit I, 12S, and 16S rRNA) for host squid species, and the glyceraldehyde phosphate dehydrogenase (*gapA*) locus for *Vibrio* symbionts, I have determined the genetic relatedness of these partners in the Indo-west Pacific as well as the phylogeography and fixation indices between populations of both squids and symbionts. Patterns of host specificity are predominant among symbiont genotypes and their phylogeography, but there is also some evidence of strain variation, which might preclude that squid populations are not the only driving force for selection of symbiont speciation.

A New Species of *Sinezona* from the Canary Islands (Gastropoda: Vetigastropoda: Scissurellidae)

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A new *Sinezona* species from the Canary Islands is compared to similar species from the European area [*S. cingulata* (O.G. Costa, 1861)] and the Caribbean [*S. confusa* (Rolán, 1996)]. Since internal anatomy is still relatively unknown for described species of *Sinezona* Finlay, 1926, this paper will focus on shell morphology. Due to their small size, scanning electron microscope imaging is ideal to show shell characteristics. Images of both species were taken using a Zeiss EVO 40 XVP. Apertural, apical and umbilical views were imaged. Shell sculpture, foramen, selenizone and protoconch characteristics were analyzed and will be discussed. This study is supported by a grant from NSF (MRI 0420726).

Revised Generic Placement of *Transenella humilis* to *Nutricola*

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The generic status of *Transenella humilis* (Carpenter, 1857) has been in question since 1982. Comparisons are made with *Nutricola* [type species *N. tantilla* (Gould, 1853)] from the Panamic Province and *Transennella* [type species *T. conradina* Dall, 1884] from the western Atlantic. Scanning electron micrographs are presented. Shell morphology including pallial sinus, anterior lateral teeth, lunule, escutcheon and amphidetic placement of the ligament were analyzed. Observations of asynchronous brooding in *N. humilis* are documented.

Gametogenesis and Size at Reproductive Maturity of *Melongena melongena* (Linnaeus, 1758) (Caenogastropoda: Melongenidae) at Golfete de Cuare, Venezuela

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Melongena melongena is subject to an intense fisheries exploitation at Golfete de Cuare and does not have any regulation controlling its catch. To determine the minimal catchable size and the reproductive season, we studied the gametogenesis of this species monthly between April 2002-March 2003 and determined size at sexual maturity. Gonads were studied by classic histological methods and the following stages were observed: early active, late active, maturity, gamete release and resorbtion. In the early active stage, previtelogenic oogonia and oocytes were observed, these were closely connected to the accompanying cells and the epithelium. In the late active stage, the oocoytes are still growing near the follicle wall, attached to it by a peduncle. At the maturity stage, the oocytes detach from the follicle wall and migrate to the lumen. During gamete release and resorbtion, few oocytes can be observed in the gonad and some yellow bodies or mastrocytes are observed. Size of mature oocytes varied between 180-200 µm in length. Gamete release of females occured in July, December and March, with three active gametogenic periods. Gonad recovery was inmediate with no resting periods. No synchrony was observed between female and male gametogenic cycles. Copulation probably occurs 1-2 months before egg laying. Minimal size at sexual maturity was 5.1 cm in shell length for females and 5.8 cm for males, and the size of maturity for 50% of the individuals was 6.8 cm for females and 6.6 for males. We suggest these as the minimal catchable size at Cuare.

The Relationship Between Body Size, Growth, and Egg Production in the Hermaphroditic Freshwater Snail, *Helisoma trivolvis*

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Among several other factors, body size has been found to influence gender role in several species of hermaphroditic snail, since when body size and egg production are linked, it is expected that larger individuals should act as females and smaller individuals as males. We tested whether such a relationship between body size and egg production exists in *Helisoma trivolvis*, a freshwater hermaphroditic pulmonate. We isolated 50 *H. trivolvis* from a laboratory population, measured shell diameter, and monitored egg production for seven weeks. We found a positive relationship between body size and total number of eggs produced, as well as body size and number of eggs per egg mass. Since body size is linked to fecundity in this species, the relative size of snails should determine, at least in part, which individual acts as male and which as female during copulation. However, the relationship between body size and egg production is not nearly as strong as it is in other snail genera. Other factors such as age, genotype, and previous experience may be important in determining egg laying capacity and therefore gender choice, and may explain the occurrence of simultaneous reciprocal copulation in this genus, but not others. In addition, we found a negative relationship between growth during this period and egg production. This relationship has been found in other pulmonates, and is evidence of resource allocation tradeoffs.

The Diversification of the Family Enidae in Turkey: an Evolutionary Perspective

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The range of the pulmonate family Enidae, with about 70 genera, extends from Japan across Asia, Middle East, Europe and North Africa to the Azores. Twenty-four genera with close to 90 species have been recorded from Turkey, indicating that a significant diversification of the family has taken place on the land masses that now comprise Turkey. Our ongoing revisions of the Turkish taxa are aimed at developing a more accurate phylogeny and a better understanding of the evolutionary history of these snails. Several conchologically similar genera found in Turkey differ anatomically (for example, *Mastus*, *Paramastus*, *Borlumastus*, *Ena*, *Merdigera*, *Megalena*), while many congeneric species are difficult to distinguish anatomically (for example, *Mastus* species, *Jaminia* species). When anatomical and conchological characteristics are taken together some generalizations are beginning to emerge. We are also creating high resolution distribution maps that are expected to offer a better understanding of not only the current ecology of these snails but also the past speciation events.

Phenotypic Plasticity in Molluscs

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Phenotypic plasticity, or the ability of a single genotype to produce multiple phenotypes, has recently gained the attention of not only evolutionary biologists, but also of ecologists and behaviorists. Molluscs have proven to be an important system for studies of plasticity, and molluscs now provide us with some of the best examples of inducible offenses, defenses, flexible life histories as well as community wide ecological impacts termed trait mediated interactions and indirect interactions. Studies on molluscs are often justified because, due to the extensive fossil record of many molluscan groups, current studies can give us insight into both patterns and processes that were historically important. I examine the types of plasticity that have been studied in molluscs, believed ecological and evolutionary implications and consequences of these plasticities, and where we should look for additional plasticities that have yet to be studied. I consider which of these types of plasticities could be detectable in the fossil record, and if there are processes that could be inferred from known plasticities that might be preserved in fossil assemblages.

Identifying the Pupilloids *Gastrocopta pentodon* and *G. tappaniana* on the Delmarva Peninsula, Eastern USA

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The North American pupilloid land snails *Gastrocopta pentodon* (Say, 1822) and *G. tappaniana* (C.B. Adams, 1842) have similar looking shells, and although *G. pentodon* tends to have a smaller, narrower, and less conical shell, in practice separating the two forms is difficult. While some workers cite habitat differences as evidence that the two forms are valid species (*G. tappaniana* occurring in moister habitats), an alternate hypothesis considers the possibility of one species whose shell morphology is influenced by the moistness of the environment. Vanatta & Pilsbry (1906, Nautilus 19: 121-128) illustrated 53 shells of the two forms but the differences between the forms are subtle. Discriminant function analysis of measurements from their illustrations gave a function that classified their shells 94% correctly. Applying this function to 577 shells from 129 localities throughout the Delmarva Peninsula, Eastern USA, revealed that both forms occur on Delmarva, with 74% of the specimens classified as *G. pentodon*. Moisture associations of plants at the sites address whether the two forms differ in the moistness of their habitats. Examination of specimens at sites where both forms co-occurred addresses whether they appear to be separate species or environmentally influenced forms of one species.

A Summary of the International Partulid Conservation Programme and its Significance for Other Group-level Managed Species

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The remarkable contribution that Partulid snail studies have made to the field of evolutionary genetics is well-documented. Likewise their tragic extinction crisis has provided a classic case-study of invasive predator-induced mass species loss. The resultant International Partulid Conservation Programme has provided the conservation community with a model for developing population management techniques and tools for species requiring management at the group (i.e. life-stage based) rather than at the individual level. This paper summarises the key elements of the Partulid management programme and discusses its wider significance for other group-level managed species.

Phylogeography of Banana Slugs (*Ariolimax* spp.) (Gastropoda: Stylommatophora: Arionidae)

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Pilsbry (1948) recognized 5 taxa of banana slugs based on differences in genital morphology: *Ariolimax* (*Ariolimax*) *columbianus columbianus, A.* (*A.*) *c. stramineus, A.* (*Meadarion*) *californicus californicus, A.* (*M.*) *c. brachyphallus,* and *A.* (*M.*) *dolichophallus.* His *columbianus* taxon occurred from central California to SE Alaska, *stramineus* from central California to southern California, and the *Meadarion* taxa were all separate populations on the San Francisco Peninsula. Our analyses of 3 mitochondrial markers (CO1, 16S, and CytB) are largely congruent with Pilsbry's taxonomy except: (1) Pilsbry's *columbianus* consists of two clades, one that occurs along the coast from Humboldt Co. to SE Alaska and a second that occurs farther south to northern Monterey Co.; we propose to resurrect the name *buttoni* (Pilsbry & Vanatta, 1896) for this second clade. (2) Clades within *Meadarion* are only weakly distinguished despite morphological differences. Moreover, *brachyphallus* has three distinct populations: northern San Francisco Peninsula, Monterey Peninsula, and Cambria. (3) There are 2 undescribed clades, one within *Meadarion* on Fremont Peak, on the Monterey-San Benito county boundary, and the other within *Ariolimax* (subgenus) on Mount Palomar, San Diego County. The distribution of these clades resembles that of other slow-moving terrestrial organisms (e.g., salamanders), indicating similar vicariant processes. Moreover, differences in genital morphology and mating behavior among the *Meadarion* clades strongly indicate rapid evolution due to sexual selection.

A Phylogenetic Study of the Invasive Land Snail Species *Praticolella griseola* (Gastropoda: Polygyridae)

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Praticolella griseola was described by Pfeiffer in 1841 from Veracruz, Mexico. This species is thought to live in Mexico and Central America with a disjunct population in South Texas, and invasive populations in the Southeastern US. Historical taxonomy in the genus *Praticolella* is primarily based on shell morphology. Molecular phylogenetic work on the genus *Praticolella* has revealed several distinctive lineages within *Praticolella griseola*. Molecular and morphometric data indicates that there are four species currently masquerading under the name "*Praticolella griseola*." This includes three invasive species, one being true *Praticolella griseola*, and two other unnamed lineages which are invasive in the southeastern US, and one unnamed species native to South Texas.

Determinate Growth and Variable Size at Maturity in the Marine Gastropod *Amphissa columbiana* (Columbellidae)

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Amphissa columbiana from the intertidal zone of San Juan Island, Washington typically have either shells with thin, delicate apertural lips, or shells with thick, robust lips. In the laboratory, thin-lipped snails grew rapidly, but were not sexually mature, while thick-lipped snails grew very slowly or not at all, and were sexually mature. These observations are consistent with the hypothesis that *A. columbiana* displays determinate growth, as has been inferred for many columbellids solely on the basis of intraspecific variation in shell form. Sizes of mature snails varied widely, with the largest individuals weighing 4.5 times as much as the smallest (wet tissue weight). I tested the hypothesis that maturation and associated shell thickening are phenotypically plastic responses to the presence of shell-crushing predators. Exposure to effluent from the crab *Cancer productus* in the laboratory had no effect on shell form or relative shell weight (an index of shell thickness), suggesting that this is not the case. Sparse data show that *A. columbiana* from subtidal habitats may mature at larger sizes than intertidal conspecifics. Because these snails have long-lived feeding larvae, intertidal and subtidal populations are likely genetically continuous; it thus seems probable that environmental factors play a significant role in explaining among-habitat, and perhaps within-habitat, variation in size at maturation in this species.

Detection of Alternative Stable States in Extant Communities: the Need for a Historical Perspective

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The possibility that different assemblages of species may exist as alternative stable states remains largely unexplored by experimental ecologists because of a variety of conceptual and experimental problems. In particular, ecologists often ignore the distinction between the processes that initiate the switch among alternative states and the positive-feedback processes that maintain those states. This is analogous to the problem of assessing the causes for the origin versus maintenance of traits in the fossil record. Appropriate experimental designs for detecting alternative states in extant systems are discussed. It is clear that good experimental designs must account for successional (i.e., historical) changes in community structure. Suggestions for improving experimental tests are proposed and unresolved issues are highlighted.

A Preliminary Review of California Fossil *Austrotrophon* and *Forreria* (Gastropoda: Muricidae: Ocenebrinae)

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Twenty-nine names have been used for Tertiary and Quaternary *Austrotrophon* and *Forreria* in California. Many of the described species were attributed to the genus *Trophon*, but that genus is restricted to the coasts of South America. Of the 29 names, two are questionably assigned to the family Buccinidae, another to the Muricid subfamily Rapaninae, seven to the subfamily Trophoninae, and one questionably to the genus *Nucella* (subfamily Ocenebrinae).

This leaves 18 names associated with *Austrotrophon* and *Forreria* in California, one of which is a figure caption misprint. Three are attributed to *Austrotrophon* and are all considered valid. California *Austrotrophon* include: *A. catalinensis* (Oldroyd), *A. kernensis* (Anderson), and *A. medialis* (Addicott). The remaining 14 names are referred to *Forreria*. A review of *Forreria* has not been completed but the following species appear valid: *F. belcheri* (Hinds), *F. cancellaroides* (Arnold), *F. carisaensis* (Anderson), *F. coalingensis* (Arnold) [syn. *T. perelegans* Nomland], *F. emersoni* Addicott, *F. milicentana* (Loel & Corey), and *F. wrighti* Jordan & Hertlein. Further review and examination of type specimens will help resolve the following species: *F. magister munda* Stewart, *T. belcheri avita* Nomland, *T. magister* Nomland, and *T. carinaensis* var. *mirandaensis* Grant & Eaton. Available specimens of *F.? bartoni* (Arnold) and *F.? lawsoni* (Clark) are poorly preserved and only questionably assigned to the genus *Forreria*.

In addition, two possible new species are found in the literature: one from the Miocene Santa Margarita Formation, and a second, from the Miocene Temblor Formation. Unfortunately specimens of the second new species have not been examined.

Temporal Community Structure and Biodiversity of Malacofauna from an Urban New Jersey Pond

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Barbour's Pond, a 55,000 m^2 pond on Garrett Mountain, is located in Passaic County, northern New Jersey, one of the densest urban regions in the United States. Despite its small size and the surrounding urban sprawl, this pond, in a heavily used public park, holds 18 species of molluscs, the most abundant being *Amnicola limosa, Helisoma anceps*, *Pisidium casertanum*, *Pisidium henslowanum* and *Physa acuta*. Monthly samples from March 2004 through March 2005 found the highest diversity in shallow waters in March and December 2004 and January 2005. Total molluscan abundance was greatest in July and November 2004, possibly reflecting young adults from late spring and autumn population expansions. May 2004 showed the lowest diversity and abundance. There is also a strong correlation between frequency of occurrence and relative abundance. Using Bray-Curtis Similarity Indices, we determined small groupings of temporal communities. The two species of *Pisidium* were always found together and usually in the presence of *Amnicola limosa*. These three taxa were found with *Physa acuta* about 90% of the time and all four with *Helisoma anceps* and *Goniobasis virginica* over 80% of the time. *Amnicola limosa* was found in every month except May 2004; *Helisoma anceps* every month except February 2005. These temporal communities could be correlated with specific environmental changes currently being examined.

Mating and Reproduction in *Deroceras* Slugs

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Deroceras is the largest genus of terrestrial slugs with a high diversity of penis morphologies and mating behaviors. The function of most of the appending external and internal penis structures, sometimes truly bizarre, is largely unknown. I review mating behavior and reproduction based on 18 species from the literature and my own observations. I analyze patterns common to all *Deroceras*, and differences between species. The general mating pattern consists of a long courtship with mutual stroking with a stimulator, a sudden penis eversion and external sperm exchange (copulation). Sperm exchange is usually very quick, but in a few species is a considerable proportion of the total mating duration. Mutual sperm exchange is the rule. Species differences involve the durations of certain mating phases, presence and nature of initial trail following, nature and intensity of stroking, including the degree of contact with the stimulator, aggressiveness of courtship behavior, and the timing of flagellum eversion. I hypothesize that the radiation of mating behaviors and associated structures may have been driven by an arms race resulting from conflicting interests of mating partners over sperm donation and usage. This could

also have increased the rate of speciation in *Deroceras*. There are indications for the presence of sperm competition and conflicting interests between mating partners: individuals mate repeatedly, can store and digest sperm, lay many egg clutches over a long period, simultaneously use sperm from different mating partners for egg fertilization, and some details of mating behavior also suggest conflict.

Steps Towards a Revision of *Hemphillia* Jumping Slugs

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The terrestrial slug genus *Hemphillia* is endemic to northwestern North America. Seven species have been named. The slugs are largely limited to natural habitats, are often hard to find, and at least some seem to have small ranges and low population densities. Accordingly, little has been published about their taxonomy and biology, yet they have assumed a relevance for conservation. The surviving type specimens of five species are useless for anatomy, and the single type specimen of *H. pantherina* is immature. The few anatomical descriptions of single species mostly suffer from a lack of detailed direct comparison with similar species. I describe the initial results of a review of this genus, based mainly on anatomy, but also including other aspects such as mating behavior. I examined the types of all species, including the holotypes, as well as new specimens from the type localities of six species and from other sites (all seven species). Genital anatomy and mating behavior indicate the existence of a sibling species of *H. malonei*.

Mollusk Survey and Basic Ecological Studies in Hells Canyon, Snake River, USA

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We surveyed and conducted basic ecological studies of mollusks in a variety of habitats in reservoirs, tributaries, and the main stem of the Snake River, Hells Canyon. We focused our efforts on threatened and endangered species and species of concern by handpicking cobbles, visual shoreline searches, and SCUBA. Results include; absence of threatened and endangered species or species of concern in reservoir habitat; range expansion of a recently discovered new species of the hydrobiid, *Taylorconcha* sp.; dominance of two invasive species, *Potamopyrgus antipodarum* and *Corbicula fluminea*; extreme rarity or absence of native unionids in the main

stem of the Snake River; and relative abundance of the limpet *Fisherola nuttalli,* a species of concern. We also related mollusk taxa abundance to environmental variables and to each other using several multivariate statistical methods. For example, *Taylorconcha* sp. abundance was directly related to *P. antipodarum* abundance, which suggests competition for shared habitats and *Taylorconcha* sp. was not found in the first 10 river miles downstream of Hells Canyon dam, which suggests unsuitable habitat in this section of the Snake River.

Discovery of Copulatory Structures in Male Helicinidae (Gastropoda: Neritopsina: Helicinidae)

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The Helicinidae represent a special family of terrestrial gastropods among only aquatic relatives having evolved independently from other terrestrial snails. Therefore, morphological features differ substantially, especially the reproductive system with separate sexes. Contrary to most related families and other terrestrial gastropods with inner fertilization, male helicinids were believed to lack special copulatory structures and the mode of sperm transfer remained doubtful.

Only recent investigations of Papua New Guinean species of the genus *Palaeohelicina* Wagner, 1905, revealed such structures. While other Neritopsina possess penes derived from the base of the right cephalic tentacle, in Helicinidae they are developed as anappendage of the inner mantle fold. Throughout the gastropods, a similar origin of copulatory structures is only found in the limnic Ampullariidae.

Morphological details will be given for *Palaeohelicina* and the presence or absence of copulatory structures in other genera will be analyzed. Functional aspects within the whole family will be discussed in the light of these new findings and structural differentiations of the female reproductive system.

Cheklist of Gastropods and Bivalves from the Coasts of Chiapas and Oaxaca, México

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The marine malacofauna of the states of Chiapas and Oaxaca, located in the southern coast of the Mexican Pacific, has been little studied. From March to June of 2004, we conducted several collections of mollusks in eight localities of both states with representative coastal environments: 1) Suchiate Estuary (sandy beach, estuary and mangroves); 2) Cahoacán Estuary (sandy beach, estuary and mangroves); 3) Puerto Madero (sandy beach, estuary and mangroves); 4) La Encrucijada (estuary); 5) La Jolla-Buenavista (coastal lagoon with mangroves); 6) Boca del Cielo (sandy beach, estuary and mangroves); 7) Puerto Arista (sandy beach); 8) Paredón (rock jetty, estuary); 9) Huatulco (sandy and rocky beaches). Additionally, the captures of a shrimp fishing vessel obtained from 62 sampling stations in the continental shelf (depths = 14.6-65.0 m) were studied. A total of 2,852 specimens were quantified and classified into 2 classes (Gatropoda and Bivalvia), 55 families, 94 genera and 170 species. The number of species of gastropods (88) and bivalves (82) was similar, but the bivalves accounted for 64.2 % of all individuals. The highest number of species was recorded in the continental shelf samples (gastropods=57, bivalves=16) and in the sandy beaches (bivalves=55, gastropods=17). Several species of genera *Gradiarca*, *Pleuroploca, Ficus*, *Fusinus*, *Chicoreus*, *Malea*, *Melongena*, *Haustellum and Hexaplex* are of commercial interest. Two species are recorded for the first time in the region.

Report on the Current Status of Introduced Species of Achatinidae and Other Economically Snail and Slug Pests in the Eastern Caribbean

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The introduction of three species of the Achatinidae, *Achatina fulica* Bowdich, 1822, *Archachatina marginata* (Swainson, 1821) and *Limicolaria aurora* (Jay, 1839) into the Eastern Caribbean is documented. The giant African snail, *Achatina fulica*, was deliberately introduced to Guadeloupe *circa* 1984. From Guadeloupe the snail was spread to Martinique by 1988, and to Saint Martin and Marie-Galante in 1995. Populations in both Guadeloupe and Martinique peaked in the 1990's and subsequently have fallen to relatively stable levels. Prior to 2000, *A. fulica* was introduced into Saint Lucia, and from there to Barbados in early 2000. On both these islands, populations of the species are increasing exponentially and spreading across the islands,

despite the efforts of the local ministries of agriculture. *Archachatina marginata* was introduced from Benin to the Saint Joseph area in Martinique in 1987, but the species has not been found since; surveys in early 2005 did not detect its presence. *Limicolaria aurora* was introduced into Martinique in 1988, and is slowly extending its distribution through central Martinique, in some areas replacing populations of *A. fulica.* The current status and distribution of three pest veronicellid slugs, *Veronicella sloanei* (Cuvier, 1817), *Veronicella cubensis* (Pfeiffer, 1840) and *Sarasinula plebeia* (Fischer, 1868) are also documented, together with that of three other pest snails, *Zachrysia provisoria* (Pfeiffer, 1858), *Bradybaena similaris* (Rang, 1831) and *Amphibulima patula dominicensis* Pilsbry, 1899. Their potential impact on agriculture and the environment in the Eastern Caribbean is discussed.

Report on the Spread of the Cuban Slug *Veronicella cubensis* (Pfeiffer, 1840) in Guam and Rota in the Northern Mariana Islands, and the Loss of Molluscan Biodiversity Apparently Resulting from Introduced Invasive Gastropod Species and the Triclad Flatworm *Platydemus manokwari* de Beauchamp, 1963

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As part of a study of snail and slug pests on subsistence and garden crops on islands in the American Pacific, the islands of Guam and Rota were surveyed for terrestrial gastropods in August 2004. Non-native, invasive species are by far the most pervasive elements of the malacofauna on both islands, with *Veronicella cubensis* reaching epidemic proportions on Rota. The Cuban slug is ubiquitous throughout synanthropic to relatively natural environments on both islands, and most of the agriculture and horticulture are being severely affected. Living specimens of native species as well as many other introduced snail species are now a rarity especially on Rota, their occurrence as documented by Bauman (1996) in the recent past indicated only by dead, eroded shells. Previously introduced snail species appear to have been decimated or even eradicated by more recent introductions, in particular *Platydemus manokwari*, and hope for the survival of native snail species in these islands appears remote.

Comparative Phylogeography of Chitons and Limpets in Southern California

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Chitons and limpets are important ecologically and are mainly dispersed by the movement of their non-feeding pelagic larvae. It has long been assumed that the biogeographic break between the Oregonian and Californian provinces occurs at Point Conception in Southern California. In recent years some researchers have contested this long held assumption and have found species of fish, copepods and other animals whose ranges span Point Conception. Authors who have reanalyzed available phylogeographic data have concluded that the vicinity of Palos Verdes Peninsula in Los Angeles is a more likely phylogeographic break than Point Conception. In our study we will investigate whether this pattern generally holds for chitons and limpets and perhaps marine molluscs in general by comparing regions of the mitochondrial genes 16S and *cox*-I (COI) from up to seven chiton species and up to six limpet species. Comparative phylogeographic analysis of the gene sequences will reveal whether Palos Verdes has been a significant barrier to gene flow. If genetic structure is consistently found between populations north and south of Palos Verdes then we can support the assertion that there has been an effective barrier to gene flow at or near Palos Verdes. If so, this physical barrier could have promoted speciation events and thus could have contributed to the impressive diversity of coastal organisms in southern California.

Taxonomic Revision of Endemic Nicaraguan Freshwater Mussels (Bivalvia: Unionidae)

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Lake Managua and Lake Nicaragua are home to a group of endemic species of unionid mussels. As with many other unionids, these species were described in the middle part of the 19th century. These descriptions were based almost entirely on conchological characters that make assessment of the systematic relationships of these species and their taxonomic placement relative to other unionids difficult to assess. These eight species have been placed into several different genera over the years e.g. *Plagiola*, *Ptychodermá*, *Micronais*, *Arotonais*, and unlike unionids from the United States and Canada have been largely ignored for the last century. Examination of existing museum holdings of these taxa represents the first stage in the preparation of a monographic revision of the unionoid bivalves of the Central Nicaraguan lakes. Specimens, including type material were photographed and measured and evaluated with respect to published descriptions and synonymies. Based on the examination of existing specimens and

descriptions the 11 nominal taxa endemic to the Nicaraguan lakes are placed in 6 species in two genera. Significant work remains to be done, including examination and description of gravid female specimens and their glochidia before a more complete picture of the number of species in the lakes and their affinities to other members of the Unionidae emerges.

Developmental and Phenotypic Integration in Bivalves: Adaptation and Evolution of the Neogene Venerid Genus *Chione*

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Morphological integration is defined as an emergent property of individual ontogenies, populations, and clades. Integration is a pattern of relationships among morphological characters at the level of the organism, but the topology and variation of this pattern at different hierarchical levels may dictate whether integration promotes or constrains evolution. We examine this problem by describing morphological integration in *Chione*, a clade of Neogene venerid bivalves. We archive the shape of individual valves using geometric morphometric landmarks, and extract from this archive estimates of developmental integration and phenotypic integration. Patterns of integration are estimated for several species from the western Atlantic and eastern Pacific, and sampling of each species includes multiple populations spanning geographic and geologic ranges.

Landmarks or traits within a shell are considered to be integrated if they are mathematically correlated. The correlations are generally associated with developmental or genetically homologous (pleiotropic) relationships. Developmental integration can be estimated as the correlations of characters with a common growth vector. This estimate of integration is an emergent group property, and may vary between populations and species. Independent of developmental integration however, are the residual correlations among sets of landmarks within a population. Both this latter phenotypic integration and developmental integration determine the responses of populations and species to agents of micro- and macroevolution, and may explain the phenotypic variability of molluscan shells. We estimate the patterns of integration using two alternative methods: (1) empirical multivariate estimates of partial correlations among landmarks, and (2) Bayesian modeling of developmental and phenotypic correlations.

Evolution of the Palau Diplommatinids and Conservation of the Land Snails of Palau and the Southwest Islands

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The western Micronesian islands of Palau comprise over 350 islands, many of which are less than 1 km^2. Babeldaob, the largest island, is only 333 km^2, and represents 80% of Palau's total land area. Despite the small size of the islands, the species richness of Palau's land snail fauna is extraordinary. This may be due in part to the varied geology of the islands, which are of both volcanic and coralline (limestone) origin and encompass high and low limestone island types, atolls, high volcanic islands, and islands that consist of both limestone and volcanic rock. The minute, endemic diplommatinid land snails are found throughout the Palau archipelago on all island types. In my 2003 survey, 39 diplommatinid species were found on 20 islands; many of these species are undescribed. In a single locality, as many as five diplommatinid species were found to co-occur. Diplommatinids are found in leaf litter, on limestone rock faces and in limestone rubble, and shell morphology roughly correlates with substrate type. Preliminary sequence data from 16S rDNA suggest complex biogeographical patterns among Palau diplommatinid species and, unsurprisingly, a need for systematic revision of the group. A thorough census of non-diplommatinid land snails in Palau was also conducted, and comprised all 16 states, including the relatively unknown and isolated low limestone Southwest Islands. Notably, live endodontids and partulids were found. Although Palau's rainforest remains largely intact, relative to many other Pacific island groups, recent development on the island of Babeldaob in particular is cause for conservation concern.

The Evolution of Exoskeleton Nucleation in Shelled Fossils and Holocene Molluscs

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Nucleation sites of $CaCO_3$ in exoskeletons of Holocene molluscs can be related to exoskeletons in Paleozoic molluscs and mollusc-like taxa. Nucleation sites have been identified from the literature. They can be divided into taxa with and without a periostracum that is secreted in a groove of the mantle edge. In those taxa without a periostracum: (1) Nucleation is within epidermal cells. The resulting sclerites are retained in cuticle secreted by epidermal cells over the general body surface (Aplacophora, geologic age unknown; Polyplacophora, *Halkieria*, Cambrian). (2) Nucleation and growth is within epidermal cells as sclerites that accreted in rows held by body cuticle, later mineralized to form a solid shell (*Maikhanella multa*, Cambrian). In taxa with cuticle restricted to periostracum: (3) Nucleation is within individual cells of the

epidermis. The prisms grow out of the cells, fuse together, and then fuse to periostracum (*Nautilus*, monoplacophorans? Paleozoic). (4) Periostracum is in three layers, outer and middle formed within the periostracal groove, the inner by mantle epithelium. The vacuolated middle layer is the site of nucleation and prism growth (*Amblema*, *Mytilus*, Holocene). (5) Nucleation is on the periostracum from ions in the extrapallial fluid between the epithelial cells of the outer mantle fold and periostracum/shell (most Holocene Conchifera). The great diversity of extant molluscs is attributed in part to the evolutionary loss of sclerites and development of periostracum and a fluid-filled extrapallial space, allowing greater freedom of movement within the shell and in the outside environment.

Understanding the Evolution and Development of Pallial Eyes in the Pectinidae

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Evolutionary developmental biology, or evo-devo, is a nascent field that aims to understand the evolution of developmental processes underlying phenotypic change across taxa. Achieving this aim requires data from diverse disciplines including genetics, embryology, paleontology, and systematics. Although evo-devo studies have been conducted in many metazoan phyla, the second largest phylum Mollusca has been so far underrepresented. Scallops, in the families Pectinidae and Propeamussiidae, offer a rich system to examine major evo-devo questions as they are: 1) diverse with 400 extant species distributed worldwide, 2) have a well-studied embryology, and 3) possess variable traits that are easily compared anatomically and developmentally. I will describe my research on the evolution of pallial eyes and their spatial arrangement in scallops. This research program will address broad evo-devo questions of the scallop eye. How is eye organogenesis initiated? What are the major contributors in determining eye symmetry - developmental constraint, historical constraint, or ecology? Is the behavior of the adult animal a good predictor of symmetry? First, I will discuss the taxonomic status of scallops and present a new phylogenetic tree based on mitochondrial and nuclear gene sequences. Then, I will present the wide phenotypic variation in the number and arrangement of eyes across species. Finally, I will place these different phenotypes in a historical context and discuss our expanding knowledge eye of development and evolution in scallops.

Flat Oysters Show Evidence for Allopatric Speciation, Ecological Transition and Introgression Among Developmentally Heterogeneous Taxa

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This study focuses on five nominal species of flat oysters that occur in multiple ocean basins and tests their phylogenetic relationships using a mitochondrial marker (cytochrome c oxidase I; COI) and nuclear internal transcribed spacer (ITS-1 and ITS-2) gene fragments. My

data were consistent with allopatric speciation expectations: all five nominal taxa have sister lineages in different ocean basins. Although the western South Atlantic *Ostrea puelchana* and the western North Atlantic *Cryptostrea permollis* differ radically in their ecologies and reproductive modes, these two species shared a common ancestor recently enough that they have not yet attained reciprocal monophyly in rooted mt gene trees. *C. permollis'* commensal relationship with sponges – the only living oyster that does not cement on hard substrates – apparently represents an evolutionarily recent ecological transition. My data also revealed that the Mediterranean *Ostreola stentina* is a member of the same sibling species complex as the western North Atlantic *Ostreola equestris* and the New Zealand *Ostrea auporia*. Analysis of COI variation showed that these three taxa are closely related but reciprocally monophyletic for this mt marker but polytomous for the slower evolving mt 16S and nuclear ITS-1 markers. Unexpectedly, *O. auporia* exhibited a nuclear/mitochondrial disjunction with a phylogenetically and developmentally distinct species, *O. chilensis*, in the North Island of New Zealand. To my knowledge, this represents the first instance of apparent hybridization among marine invertebrates with different developmental modes.

Diversity of Terrestrial Snails on the Three Largest Islands in the Louisiade Archipelago, Papua New Guinea

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The Louisiade Archipelago, a group of volcanic islands and coral islets, with a total area of approximately 1600 km^2, lies about 300 km east of the New Guinea mainland and 400 km west of the Solomon Islands. The Louisiades are at least 15-20 million years old but more likely were formed 40-60 million years ago and have apparently never had a land connection with the New Guinea mainland. The archipelago's physical isolation and great age combine to provide considerable opportunity for the evolution of a distinctive fauna. However, this fauna has remained largely unknown, especially for invertebrates, including terrestrial snails. Only a few brief surveys and small collections made in the mid to late 19th century led to the description of the approximately 35 species of land-snails known from the archipelago. Low sampling intensity and poor geographic coverage combined with high levels of endemism suggest that land snail diversity in the archipelago is under-sampled, a view supported by ten weeks of field surveys in January 2003 and April-May 2004 on the three largest islands in the Louisiade Archipelago: Misima (St. Aignan), Vanatinai (Sudest, Tagula) and Yela (Rossel). These surveys uncovered many undescribed snails, nearly all of them endemic to a single island.

A Re-description of *Marionia rubra* (Rüppell and Leuckart, 1831)

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The morphology and anatomy of 15 preserved specimens from Okinawa, the Philippines and Tanzania are closely examined. Based on general appearance, digestive armature and reproductive systems, these animals are similar enough to comprise a single species. However, the photographs of the living animals vary widely in color and to a lesser extent pattern. Color/pattern variations occur within as well as between localities, and do not appear to be on a geographic gradient. Other evidence suggests that variability may be even greater than that observed in the present study.

The taxonomy of the tritoniid nudibranchs of the Indo-Pacific region remains poorly understood. Early descriptions based only on external features, and inconsistent later descriptions of important anatomical characters are only the first obstacles for workers to overcome. Some animals are known only from their original description, and may not have been collected and examined again. In addition, there remains some controversy over the characters used to delineate the existing genera, and over which genera and species are valid.

Descriptions of the animals in the present study are compared with published descriptions of *Marionia viridescens* (Eliot, 1904), *M. albotuberculata* (Eliot, 1904), *M. dakini* (O'Donoghue, 1929) and *M. rubra* (Rüppell and Leuckart, 1831). Of these, *M. rubra* is believed to be the earliest valid name for this species, and the rest are proposed as junior synonyms.

Stable Isotope Growth Profiles of Holocene and Cenozoic Mollusks

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Oxygen and carbon stable isotope concentrations were measured from carbonate samples taken along the incremental growth of molluscan shells. Isotopic data were used to determine and compare shell growth histories of six Holocene and fossil genera of mollusks: three genera of gastropods – *Triplofusus*, *Fasciolaria*, and *Beringius*, and three genera of bivalves – *Dosinia*, *Anadara*, and *Codakia*. These taxa were selected to check for compatibility of results between fossil and modern genera from similar environments. Furthermore, the isotopic profiles were used to determine a latitudinal change in isotopic values from low to high latitude localities. Comparison between isotopic profiles of modern and fossil congeneric species allows insight into seasonal shell growth rates, metabolic activity and environmental conditions. Isotopic profiles of gastropods exhibit more coherent growth profiles and are generally longer lived than the examined bivalves. Shell growth differs between congeneric fossil and modern species, probably as a result of different environmental conditions during the Pleistocene. Holocene specimens were collected from the Gulf of Aniva, Gulf of California, Bahamas, Florida Keys,

and Gulf of Mexico. Fossil specimens were collected from the Early Middle Miocene of Kamchatka and the Pleistocene of southern Florida. Data appear to be reliable for most specimens, showing that accurate proxy data can be obtained from isotopic studies in marginal-marine environments. Oxygen isotope ratios were also used to infer ambient seawater temperatures during the deposition of each shell. Calculated temperatures offer significant insight into the paleoceanography of the Pleistocene southern Florida embayment and early middle Miocene climatic optimum in the North Pacific.

Differential Expression of Vetigastropod Hemocyanin

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Molluscan hemocyanins are blue copper-containing respiratory proteins that are found in a number of gastropods in two immunologically distinguishable isoforms. In general, these isoforms do not occur in equal molar ratios but are differentially expressed. In *Haliotis tuberculata* (Haliotidae), for example, the two isoforms are present in an average molar ratio of 9:1, whereas in *Megathura crenulata* (Fissurellidae) the average molar ratio is 1:3. Analyses of the complete cDNAs of these four hemocyanin isoforms do not reveal any significant codon bias or any abnormal amino acid accumulation. Quantification of isoform specific mRNAs within these species show that different amounts of transcripts exist that, however, do not correspond to the protein amounts observed. Additionally, we could show that the two hemocyanin isoforms of *Haliotis asinina* are expressed in a tissue-specific manner. For that purpose, we are investigating the hemocyanin genes with special focus on promotor regions. Preliminary results show that the promotors possess typical TATA-boxes and a number of other theoretically identified cis-acting elements. Thus it appears that expression of these isoforms is differentially regulated by transcriptional control mechanisms and in addition by the translational machinery and/or protein turnover rates.

New Morphological Data for Pleuroceridae (Gastropoda: Cerithioidea): Implications for Monophyly and Affinity of the Family

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The family Pleuroceridae comprises one of the most abundant and species rich assemblages of limnic mollusks occurring in North America and Eastern Asia. In North America, they are represented by 7 genera and estimates of ~160 species are currently considered valid. Despite their ecological importance, their systematics at all levels remains poorly understood. A rigorous systematic revision of all species and genera is lacking and uncertainty

exists as to the precise limits of the family. Moreover, all taxonomic treatments of the family have been done in the absence of a broad comparative understanding of morphology.

B.C. Dazo's classic account of *Pleurocera acuta* and *Goniobasis livescens* is the most thorough work available for pleurocerid anatomy. However, this study was completed long before our present knowledge of freshwater cerithioidean anatomy was in place. In particular, we now have a much more thorough understanding of the structure, function and homologies of the pallial gonoduct as well as other organ systems (e.g. midgut, kidney) and their phylogenetic utility.

Consequently, especially given the persistent paucity of anatomical data available for the family, the anatomy of these two species is re-described, with particular emphasis on the re-interpretation of pallial oviduct homologies; features not covered by Dazo (midgut and kidney) are newly described. This analysis reveals a number of presumably synapomorphic features unique to pleurocerids as compared to other limnic lineages in characters of the midgut, albumen gland and pallial kidney extension. The implications of these findings for clarifying the monophyly and affinities of the Pleuroceridae are discussed.

Reproductive Behavior of the Dioecious Tidal Snail, *Cerithidea rhizophorarum* (Gastropoda: Patamididae)

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The dioecious snail *Cerithidea rhizophorarum* is found throughout the coasts of the western Pacific up to the Tohoku district northward in Japan. It inhabits reed grassland and mangrove forest on mud flats. In Kagoshima prefecture, this species are commonly found in a mangrove forest with *Kandelia candel* and *Hibiscus hamabo* trees on a mud flat located at the mouth of Atagogawa River in Kiire. Interesting mating and tree climbing behavior of this species were studied on this mud flat, for approximately two years from April 2000 to May 2003.

Mating behavior was observed in July and August 2002. The time of commencement duration and termination, were recorded for each copulation. The peak of matings during daytime was seen 1 to 2.5 hours before the lowest tide, and that during nighttime between 1 hour before and after the lowest tide. However, the mating almost did not occur on cloudy days.

Climbing behavior was observed in an area of 100 square meters where only *Kandelia candel* trees existed. The number of snails on the tree was counted and daily activity of the snails on trees was monitored in summer and winter, counting the number of the snails on the tree every one hour throughout the day. The snails were mainly found on the mud from spring to summer, frequently climbed up the tree during particular times in the summer, and most individuals were seen on trees and motionless during winter.

Detecting Stability and Change in Fossil Communities: the Need for Temporal- and Scale-dependent Perspectives

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The strict application of ecological patterns and processes to the fossil record is severely limited because of loss of soft-bodied flora and fauna, difficulties of measuring biomass, virtual inability to reconstruct direct biotic interactions, and most significant of all, time averaging of individuals which never lived contemporaneously. Documented patterns of paleocommunity stability should more accurately be compared to the neo-ecological concept of resilience rather than resistance. While succession and other short-term processes can only be examined under unique preservational conditions, time-averaged "paleocommunities" possibly spanning thousands of years do allow for the study of patterns and processes in evolutionary paleoecology.

Molluscs are a good system with which to ask paleoecological questions because they exhibit a range of trophic strategies, are geographically distributed, have a long fossil record, and inhabit a number of ecological and environmental niches. In addition, many taxa have good preservational potential. However, even with molluscs, detailed sedimentological, paleoenvironmental, and taphonomic studies should be employed to assess the limitations of paleocommunity analysis.

For example, in the right depositional systems, paleocommunities can preserve local geographic patchiness and short-term environmental excursions; even with time averaging and transport of individuals, a great amount of small-scale geographic and temporal resolution can be obtained using the appropriate proxies given preservational biases. In this talk, many different proxies including species abundance, individual abundances, species presence/absence, comparison of left and right valves, morphometric and paleocommunity structure are compared to reconstruct different paleoecological conditions exhibited by mollusk-dominated Neogene marine fossils of the Dominican Republic.

The Year of the Pond Snail

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The hermaphroditic pond snail *Lymnaea stagnalis* has long been used as a laboratory model for the study of neurohormonal regulation of reproduction and growth. In parallel, the allocation of resources towards reproduction, growth and maintenance has been studied as a means to understand the hermaphrodite's life-history. To gain insight into the seasonal changes of resource allocation towards female and male function, as well as towards body growth we have collected snails in a Dutch ditch for over two years on a monthly basis. The weights of the prostate gland and albumen gland were determined as well as body size and (dry) weight. Animals that survive the winter months (December to March) copulate at the start of spring. A few weeks later, egg masses appear from which the next generation hatches, grows and matures

in about two months. As last year's generation dies off, the new one becomes sexually active. This means that there is little opportunity for copulation between generations. The last egg masses, laid by the new generation, are laid around the autumnal equinox. Towards summer, both generations show a decrease in dry weight density suggesting that the snails apply the acquired energy to reproductive output instead of storing it. The results obtained in the ditch are compared with laboratory studies on the physiology of reproduction, as well as on sex allocation.

Missing Pieces in the Speciation Puzzle: an Example of the Palaeontogical Imperative in Interpreting Biogeographic Patterns in a Neotropical Marine Gastropod Radiation

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Inference of speciation mechanisms and sister species relationships are staples of evolutionary analyses, but are done almost exclusively on extant taxa. Distributions of living animals are generally taken as representative of the interplay between the biogeography of ancestral lineages and the (often vicariant) mechanisms that drove divergence. Full sampling of all members of a clade is correctly encouraged, but commonly excludes all but the denizens of the thinnest slice of geological time – time zero, the Holocene. The missing players of extinct taxa and the shifting stage of changing distributions through time are often brushed over or omitted as being too challenging. Detailed sampling through space and time of a species-rich molluscan clade allows us to test whether these simplifying assumptions are justified, or whether they bias our results. I present an example – the Neotropical turrid genus *Polystira* – that consists of narrow and widespread, rare and abundant, fossil and Holocene species, to illustrate the contribution fossils make to understanding present day biogeography. This genus consists of numerous living and extinct cryptic, undescribed species whose discovery has been expedited by a combination of molecular genetic analyses with conchological studies of fossil and Holocene specimens.

Biomineralization in the Radula of the Aplacophoran Mollusk *Helicoradomenia* (Solenogastres)

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As the major feeding organ in mollusks, the radula is frequently exposed to high mechanic stress. In general, it is composed of a flexible membrane with a set of considerably harder teeth attached to it. Specialized cells of the radular sheath, the membranoblasts and odontoblasts, constantly regenerate both the membrane and teeth while worn teeth are shed into the mouth cavity or occasionally retained within the subradular pocket. The hardness of radular teeth is due to biomineralization processes that occur within the chitin-rich organic matrix of

newly produced teeth. These processes are best known for chitons (Polyplacophora) and some gastropods but biominerals also occur in the radula of caudofoveates (Caudofoveata = Aplacophora, Chaetodermomorpha).

Here, the first evidence for the presence of biominerals in a solenogaster radula is presented, and ultrastructural features of the radula-producing cells and young teeth are shown. The radula of *Helicoradomenia "tica"* (Solenogastres = Aplacophora, Neomeniomorpha) was investigated by means of transmission electron microscopy, scanning electron microscopy, and energy-dispersive X-ray microanalysis. The analyses show that the level of overall mineralization is low but that a variety of mineral-composing elements do occur including calcium, phosphorus, iron and zinc. Concentrations of these elements change gradually over each tooth resulting in considerable differences in the chemical composition between basal radular plates and distally located denticles. Specific biomineralization of radular teeth thus seems to be a broader trait of the molluscan radula.

Impacts of Urbanization on the Biodiversity of the Imperiled Snail Fauna (Gastropoda: Prosobranchia: Pleuroceridae) of the Cahaba River, Alabama, USA

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The conservation of the Pleuroceridae is of concern in the Mobile River Basin (MRB) since 31 of 38 extinct gastropod species from this drainage are pleurocerids. The fauna of the Cahaba River, as a global hot-spot for pleurocerid diversity, is of particular concern. Flows in the river are not regulated by dams, so gastropod diversity has not been affected by habitat alteration due to impoundment like other major MRB tributaries. Ongoing urbanization within its watershed, however, is expected to have consequences for its snail fauna. A 1993 survey documented 23 pleurocerid species among 109 sites in the drainage. Changes in land cover from 1992 to 2004 were quantified using GIS for 10 of these. Five sites showed a 13-36% increase in urban land cover; five showed no change. *Elimia cahawbensis*, *E. carinifera*, *E. carinocostata*, *E. clara* and *Pleurocera vestita* occurred among these sites during 1993 (S = 0-4 spp./site) A comparison of species occurrence in 1992 and 2005 showed no change in S at 6 sites, while three lost 1 species, and one lost 3 species. However, reductions in S were not correlated with changes in land cover. Factors not directly correlated with urban land cover may thus be contributing to losses of snail diversity in the MRB.

Inducible Defense in a Marine Snail: Cue Sensitivity and the Scaling of Trade-offs

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Predator-induced defenses appear to be ubiquitous in marine systems yet little attention has been paid to how they may shape large-scale patterns of phenotypic variation. Here I consider how the invasion of the green crab (*Carcinus maenas*) into the Gulf of Maine has led to the evolution of geographic differences in shell thickness and shell thickness plasticity in the marine snail *Littorina obtusata*. Because the historical impact of *Carcinus maenas* in the Gulf of Maine changes with latitude, I examined how geographic differences in shell thickness plasticity may have evolved in response to different risk cues. I also examine how trade-offs in snail body mass, which influence snail fecundity, correlate with the magnitude of induced defense employed by the snail. Finally, theory predicts that natural selection should minimize the impact of trade-offs associated with an inducible defense, thereby making them difficult to detect experimentally. I explore this issue by explaining (1) why such trade-offs are indeed readily detected in marine snails, and (2) why the scaling of such trade-offs shows no geographic differentiation when one would expect otherwise.

Texas Seashells: a New Illustrated Guide

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The last comprehensive work on Texas seashells was compiled by Jean Andrews over 30 years ago (1971, 1977). Her book *Shells and Shores of Texas* describes approximately 350 species of molluscs. In a collaborative effort, we are preparing an updated and expanded book on Texas seashells. Presently, the list of molluscs in the marine environments of Texas equals over 1400 species from the estuarine shoreline to the deep Gulf of Mexico. Because of the large number of species and inaccessibility of many of these molluscs, principally from older collections of offshore deep water habitats, accounts of molluscs with descriptions and photographs will be confined to habitats not exceeding 18 m (60 ft), but will also include Stetson Bank and the Flower Garden Banks. Approximately 750 species of molluscs are known from these habitats, and will be individually illustrated and described in the book. A complete checklist of all species including depth ranges and habitat will be included in the book along with a research history of conchology/malacology in Texas, biology and ecology of classes and families of molluscs, and favorite collecting habitats and localities.

Crossing the Pond: Dorid Nudibranch Strategies for Transatlantic Dispersal

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Thirty-four species of dorid nudibranchs have amphiatlantic geographic ranges in the Northern Hemisphere, with populations on both sides of the Atlantic Ocean. The other 227 species are restricted to either the east or the west coast. Larval transport has been traditionally considered the main mechanism for nudibranch dispersal and gene flow between amphiatlantic populations. However, some amphiatlantic species have direct development or short-lived larval stages, suggesting the possibility of alternative dispersal mechanisms.

There is a statistically significant higher number of bryozoan/tunicate/barnacle-feeding species with amphiatlantic ranges compared to sponge-feeding species. These differences suggest that factors other than larval transportation may affect dispersal of dorid nudibranchs across the north Atlantic. Bryozoans, tunicates and barnacles are some of the most common and diverse organisms on floating debris and slow moving vessels, while sponges are much more uncommon and scarce. Nudibranchs have been found actively feeding and reproducing on bryozoans fouling floating objects. The results obtained suggest that adult transportation on floating objects may account for the transatlantic ranges of some species. However, with the available data, the amount of larval dispersal influencing amphiatlantic distribution in the boreal region cannot be determined.

Unexpected Diversity Recovered with Experimental Wood Deployments in the Deep North Pacific Ocean

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Wood and other vegetation from terrestrial systems is sometimes transported to the open ocean where it sinks. Such wood-falls are argued to be of great ecological importance in the deep sea due to the otherwise scarce resources they offer, but the animals that exploit these resources remain poorly known. To document the wood-fall fauna of the deep North Pacific Ocean, in 2002 sets of 18" long lengths of fir and oak were deployed at seven sites between 3230 and 1550 m depth from 41° to nearly 48° N, all at least 100 miles off the North American coast. Deployments were made with Remotely Operated Vehicles (ROV's) which allowed them to be precisely located for recovery. Recoveries in 2003 were made with the ROV's *ROPOS* and *Jason II*; in 2004, recoveries were made with the DSV *Alvin*.

Dominant among the wood-associated molluscan fauna in both years were wood-boring clams of *Xylophaga* Turton. These are among the most abundant and familiar colonists of deep-sea wood-falls, considered to be the deep-sea ecological equivalent of teredinids (ship-worms). Although only one species, *X. washingtona* Bartsch, 1921, had been reported from the Northeast

Pacific, five new species of *Xylophaga* were collected from the recoveries, as was a new species of *Xylopholas* Turner, 1972, a genus previously known only from above 400 m depths in the Atlantic Ocean. Newly discovered aspects of the biology of these species, their distribution and evidence of ecological interactions within the wood-fall are reported.

Taxonomic Distribution and Phylogenetic Utility of Gender-associated Mitochondrial Genomes in the Unionoida (Bivalvia)

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Three bivalve orders (Mytiloida, Veneroida, and Unionoida) are known to exhibit a unique mode of mitochondrial DNA inheritance termed doubly uniparental inheritance (DUI). In this type of inheritance, there are two distinct genomes present: a female transmitted (F) mitotype and a male transmitted (M) mitotype. Three of the five families within the Unionoida have been found to exhibit DUI (Unionoidae, Margaritiferidae, and Hyriidae). All tissues sampled from individuals in the Iridinidae and Mycetopodidae yielded F sequence. Published sequences of the junction between the cytochrome *c* oxidase II (*cox2*) and cytochrome *c* oxidase I (*cox1*) genes of M unionid genomes revealed an approximately 600 bp extension of the 3' end of the *cox2* gene which is absent from the F genome. We detected F as well as M length variation in the *cox2* gene with a much greater level of variability in the latter. Amino acid compositional analyses suggest that the M *cox2* extensions are relatively hydrophobic and analyses of M *cox2* extension secondary structure revealed the presence of a variable number of transmembrane helices (Unionoidae 3-5; Margaritiferidae 0; and Hyriidae 4). Previous phylogenetic analyses of M and F *cox2* - *cox1* sequences reveal separate F and M clades that exhibit similar topologies. Analyses presented herein were conduced using separate M and F *cox2* - *cox1* sequence matrices as well as concatenated M and F *cox2* - *cox1* sequences.

Examination of Lineage Diversity and Isolation of *Oreohelix strigosa cooperi*, Black Hills, South Dakota

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The Rocky Mountain Snail, *Oreohelix* (Oreohelicidae), is one of the most abundant and characteristic land snail genera in the Western United States. The genus consists of

approximately 120 species, mostly restricted to moist alpine environments. We have begun to examine the lineage diversity and biogeography of *Oreohelix* using primarily molecular systematic approaches. Our goals are two-fold. We are particularly interested in lineages that have been listed as conservation concerns. High endemicity within *Oreohelix* has led federal and state agencies to list or propose listing (as threatened or endangered) several species and subspecies (e.g. *O. peripherica wasatchensis*, *O. strigosa cooperi*). A complementary goal is to understand the processes that have led to distributions of *Oreohelix* lineages in the Western United States. Here we focus on the Black Hills of South Dakota and Wyoming, a disjunct portion of the Rockies that appears to isolate mountain snails like *Oreohelix* due to intervening unfavorable habitat. We examine lineage diversity within the Black Hills and relationships of lineages to adjacent populations in Montana and Wyoming. In particular, we examine *O. strigosa cooperi*, a subspecies found within the Black Hills that has recently been proposed for state listing, to determine its uniqueness and extent of isolation.

Genetic Structure of *Biomphalaria glabrata* Populations Sampled from a Schistosomiasis Endemic Region

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Seven microsatellite loci were used to genotype 308 *Biomphalaria glabrata* from 17 populations in Virgem das Gracas (Brazil), a schistosomiasis-endemic area. Snail populations were sampled from a variety of environments within a 3 kilometer range, and snail genetic population structure was used to assess gene flow patterns. There was a significant isolation by distance when comparing ln distance with st values. Given the marked genetic structuring of these populations, gene flow appears to be very low even between geographically close populations. In general, there was a reduction in the expected number of heterozygotes over all loci and over most populations, indicating a high level of selfing and/or close inbreeding. This even occurred in snail populations parasitized by the castrating trematode, *Schistosoma mansoni.* Results from this study are important for understanding the potential for local adaptation between schistosomes and their snail hosts at this epidemiologically relevant scale.

Phylogenetics of the Genus *Isognomon* (Bivalvia: Pterioidea): Initial Findings and Cross-isthmus Invasions

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The genus *Isognomon* is a group of marine, pantropical oysters known for their multivincular hinge ligaments and extreme plasticity in their shell morphology. This plasticity often results in continuous grades of shell shapes and has led to much controversy within the systematics of the group. We have examined soft tissue and stable shell character morphology in several members of this genus as well as analyzing Cytochrome Oxidase I sequence data for a smaller subset of this genus. While the analysis of this genus is far from complete, the findings up to this point shed light on some sub-generic affinities within the genus as well as on the evolution of the Caribbean species and the Pacific sister taxa from which they arose.

Morphology and Function of Invertebrate Hemocytes: Physiological Effects of Stress in *Aplysia californica*

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We are interested in how environmental factors affect the physiology and immune responses of marine invertebrates. Initial work has focused on characterizing the circulating hemocytes in *A. californica.* A single type of hemocytes was observed using morphological techniques (LM, TEM, SEM) and differential centrifugation on metrizoic acid gradients. A typical hemocyte is ~6 _m in diameter with a central nucleus, surrounded by many filopodia. The cytoplasm contains large amounts of glycogen along with a few granules positive for acid phosphatase. Hemocytes rapidly adhere to substrates, exposing several large lamellipodia, and are capable of phagocytosing yeast particles.

Tide pool studies were arranged in order to assess the effect of air exposure on *Aplysia.* Hemolymph samples were collected from animals submerged in pools and animals exposed above the low tide mark. Animals found exposed were placed under water, and submerged animals were placed out of water for one hour each. Hemolymph samples were withdrawn again and analyzed for total hemocyte count (THC), blood glucose levels (sigma kit, GAGO-20) and protein concentration (Bradford assay). Preliminary data shows a significant increase in circulating hemocytes in animals exposed for extended amounts of time, and decreased THC in submerged animals. Glucose and protein assay results will be described. Further lab studies will determine if THC, protein and glucose assays are correlated with osmoregulation.

A PCR-based Method for Identifying Individual Larvae of Molluscs

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Taxonomic identification is problematic for mollusc larvae that lack species-specific morphological characters. We developed a molecular method for identifying gastropod and bivalve larvae to species or genus. Larvae (130-300 _m) were sampled from southern Californian estuaries, sorted by gross morphology, photographed and frozen. Genomic DNA was extracted from individuals or pools of 2-10 morphologically identical larvae. Sequences of the mitochondrial cytochrome oxidase 1 gene, widely used in genetic studies of invertebrates, were amplified by polymerase chain reaction (PCR) and compared to the NCBI database. Larval species was determined by 99-100% sequence identity over 380-560 base pairs; an 83-92% match identified the likely genus while indicating that the exact species was missing from the database. Sequences were obtained from 70% of veligers, half of which were confidently identified to species. Common veligers included *Bulla gouldiana*, *Haminoea vesicula*, *Crepipatella lingulata*, and *Crepidula onyx*. Some veligers with affinity to *Echinolittorina* or cephalaspideans could not be identified to genus, highlighting limitations of the public database. A quarter of pediveliger samples yielded sequences. The most abundant pediveliger in Newport Bay was the invasive mussel *Musculista senhousia* which dominated the plankton in September 2004 (1,696 $\pm$ 614 larvae per m^3); other pediveligers had affinity to the invasive clam genus *Corbicula* sp. This method should provide information on reproductive seasonality and larval abundance of invasive bivalves, important for wetland preservation. We are also assembling a visual key to identified larvae of common species, and developing taxon-specific probes to improve results for bivalve and polychaete larvae.

Genetics of Sex Ratio Variation in the Apple Snail, *Pomacea canaliculata*

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The population sex ratios in the apple snail *Pomacea canaliculata* are nearly 1:1, but the brood sex ratios vary almost continuously from all male to all female. Here I report results of experiments to study genetics of the sex ratio variation. First, I studied regressions of the offspring sex ratio on the sex ratios of the parents' siblings as well as correlations in the brood sex ratios between sisters or brothers. There were significant positive relationships between the offspring sex ratio and the sex ratio of the mother's siblings (slope = 0.28), and between the offspring sex ratios of two sisters (r = 0.41). On the other hand, the father-offspring regression (slope = 0.10) and correlation between two brothers (r = -0.13) were not significant. These patterns differed from predictions using typical cytoplasmic sex factors, sex-ratio genes or polygenic sex determination. Next, I studied the effect of each parent on the brood sex ratio, by exchanging partners among mating pairs. There were positive correlations between sex ratios of

half-sib broods of the mother (r = 0.42) and the father (r = 0.47). Moreover, the correlation between full-sib broods was nearly 1 (r = 0.92). Thus, both parents contributed equally to the sex ratio variation. The most likely mechanism of the sex ratio variation involves a small number of nuclear sex-determining genes that act additively.

The Genus *Thyasira* Leach, 1817 (Lucinoidea: Thyasiridae), in the Magellan Region and Adjacent Antarctic Waters

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Thyasira Leach, 1817, is a worldwide genus of infaunal bivalves, occurring from shallow to abyssal waters, including oxygen-poor and hydrogen sulfide-rich environments. Five species of the genus were reported from the Magellan Region and adjacent Antarctic waters: *Thysira falklandica* Smith, 1885, *Thyasira fuegiensis* (Dall, 1889), *Thyasira magellanica* Dall, 1901, *Thyasira bongraini* (Lamy, 1910) and *Thyasira debilis* (Thiele, 1912). At present, there is confusion on their identity, arising from the unprecise original descriptions, based on few, subtle and widely variable shell characters. Soft part anatomy of the species is completely unknown. In this study a revision of the thyasirids occurring in the Magellan Region and adjacent Antarctic waters is performed by studying shell and gross external anatomy. The study is based on material collected during several field trips at the Magellan Region and the Scotia Arc Islands. Shell morphology was studied by SEM and anatomy by dissection under stereoscopic microscopy.

In addition to the five species of *Thyasira* previously reported for the area, 3 species new to science were found during this study. Most of the species here examined showed great intraspecific variability in shell morphology. This fact is in contrast with the soft part anatomy (e.g. the morphology of the gill and food) that proved to be appropriate to recognize different species.

The Diversity of Scissurellidae and Anatomidae in Sub-Antarctic and Antarctic waters: Preliminary Results

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Scissurella and *Anatoma* are two genera of worldwide distribution classified in Mollusca, Vetigastropoda, occurring from the intertidal to abyssal depth. Twelve nominal species of these genera were described from Sub-Antarctic and Antarctic waters: *Scissurella conica* d'Orbigny, 1841, *S. supraplicata* Smith, 1875, *S. obliqua* Watson, 1886, *S. dalli* Bartsch, 1903, *S. euglypta* Pelseneer, 1903, *S. clathrata* Strebel, 1908, *S. petermannensis* Lamy, 1910, *S. eucharista* Melvill

& Standen, 1912, *S. timora* Melvill & Standen, 1912, *S. amoena* Thiele, 1912, *Schismope subantarctica* Hedley, 1916 and *S. medioplicata* Thiele, 1925. The species are of small size (0.8–2.5 mm) and have intricate sculpture by which species and genera are distinguished, yet all species were described before the invention of the scanning electron microscope. Thus, the proper placement and systematic affinity are unresolved in several instances. The objective of this study is to provide some preliminary results on the systematic revision of scissurellids and anatomids from Sub-Antarctic and Antarctic waters.

This study is based on the material collected during several field trips to the Magellan Region and the Scotia Arc Islands, and museum collections. Shell and radula morphology is studied by SEM; anatomical studies are based on dissections under stereoscopic microscopy and histology.

Preliminary results suggest the presence of several synonymies and erroneous application of generic names, because of the inadequacy of old observational techniques (most species were described only from stereoscopic microscope observations) or the poor condition of the studied materials (masking for example the protoconch morphology).

Federal Efforts to Exclude Snails and Slugs Associated with Agricultural Imports

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At ports of entry in the United States some agricultural cargo, carriers, mail, and baggage are inspected to detect unwanted snails, slugs and other pests. Federal permit and phyto-sanitary inspection requirements strive to allow entry only to pest-free, non-prohibited agricultural cargo. Even with the multi-faceted federal inspection activities that are in place, the potential for new mollusk pest introductions will be ever present, and when combined with the invasive mollusk pests already present, America's native malacofaunas as well as the agricultural, hydrological, economic and other resources, remain at risk.

CONTRIBUTED PAPER

Editors' Note: Because of timing coincidences, this report on the August 2009 meeting of the Sociedad Mexicana de Malacología can be included in this Annual Report of the 38th meeting of the Western Society of Malacologists. The two societies will hold a joint international meeting in June 2011, at La Paz, Baja California Sur, México, under the Presidency of Esteban Félix Pico. Mark your calendars and plan to attend this significant bilingual scientific interchange.

XI Reunión de la Asociación Nacional de Malacología y Conquiliología (XI RENAMAC): a Report on the August 2009 Meeting

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The National Mexican Association of Malacologists and Conchologists held its eleventh annual meeting in the Centro Internacional de Vinculación y Enseñanza on the lakeside campus of Universidad Juárez Autónoma de Tabasco (UJAT), 24-28 August 2009. Dr. Luis José Rangel Ruiz (Laboratorio de Malacología, División Académica de Ciencias Biológicas) was the gracious host President. Institutional hosts of this meeting were UJAT, Sociedad Mexicana de Malacología A.C. (SMMAC), and the Comisión Nacional para la Biodiversidad (CONABIO), with additional support from the Secretaría de Turismo del Estado de Tabasco.

The meeting involved over 65 participants from 4 countries and at least 12 states of Mexico (Figure 1). There were representatives from 11 official institutions, with a huge range of ages, experience, background and professional expertise. The event had one day of four pre-conference workshops, 3 days of conferences, and a one-day field trip to view the fauna and flora of local rivers, ranchlands and jungles, and the Mayan archaeological ruins of La Palenque in the adjacent state of Chiapas.

Workshops and Presentations

Workshops emphasized the practical, ecological and theoretical: "Biotechnology of Bivalve Cultivation" (by Esteban Félix Pico of Baja California Sur), "Introduction to the Geometric Morphology of Molluscs" and "Preparation of Manuscripts for Scientific Publication" (by Roberto Cipriani of Venezuela), and "Theories of Oyster Cultivation: Basic Principles" (by Andrés Góngora Gómez of Sinaloa).

Themed sessions of papers addressed archaeology and paleontology, biodiversity, ecology, biology, biogeography, collections, conservation and contamination, taxonomy and systematics, reproduction and genetics, and cultivation. There were 54 oral conferences and 14 posters, with exhibits of 3 mollusc collections.

Appropriately, conference presentations were held in mollusc-named rooms, Sala "Tote" (= *Pomacea flagellata*, México's largest freshwater snail) and Sala "Shutti" (= *Pachychilus*

chrysalis, a FW snail of Tabasco and Chiapas, eaten by local residents).

Of particular interest to one of us (HB), were the opisthobranch presentations on Yucatán biodiversity and biogeography (Jazmín D. Ortigosa Gutiérrez, N. Simões & G. Calado); biodiversity of Estero de Urias and the Mazatlán coastline (Christian Samuel Castillo Flores, M.-A. Ortiz Arellano, J. C. Román Reyes & M. Nieves Soto); provincial level biogeography, from Point Conception, California, to Punta Aguja, Perú (HB); holdings in the Colección Nacional de Moluscos (Andrea Zamora & Edna Naranjo García); a new species of tritoniid, the first known to feed on zoanthids, not alcyonarians (H. Bertsch, Á. Valdés & T. M. Gosliner); and the systematics and phylogeny of *Navanax* and the Aglajidae (Andrea Zamora).

Student posters were remarkably well done, and the judging committee praised them all when announcing the prize winners (Figure 2). First place poster award was shared for "Fauna Malacológica con Énfasis en Micromoluscos de Isla Socorro, Archipiélago de Revillagigedo, Colima, México" (by Isaura Rebeca Zamora López and Brian Urbano Alonso) and "Malacolofauna Asociada a Substrato Coralino de Majahual, Quintana Roo, México" (by Iris Dinora García Tello, Jorge Luis Garcés Salazar and V. Solís Weiss). Second and third place awards were presented respectively for "Bivalvos de México en la Colección Malacológica 'Dr. Antonio García Cubas'" (by Orquidea Lozada Flores and Martha Reguero Reza) and "Diversidad de Opistobranquios del Litoral de Acapulco, Guerrero, México" (by Berenice G. Martínez Vázquez, Pedro Flores Rodríguez, Rafael Flores Garza and Sergio García Ibáñez).

Field Trip to Palenque (*Lakanhá* = Agua Grande, Big Water)

Reunion participants were offered a selection of field trips to various cultural and touristic sites in the city of Villahermosa and the surrounding areas. About a dozen of us toured the incredible (and only partially excavated) Mayan ruins of Palenque, in the adjacent state of Chiapas. Our guide was bilingual in Mayan and Spanish, and provided us with intriguing information about the names, uses, and significance of the various temples and administrative buildings that we scrambled over, under and through!

The stone walls were covered originally with a seashell-based stucco, painted with hues of red, blue, yellow, green and ochre. We were astounded at the inestimable tons of oyster and other marine shells that had been collected, crushed and processed for the buildings' outer layers,

Palenque (founded ~150 B.C.E, abandoned ~900 C.E.) reached it apogee as a regional center in the Usumacinta river basin from 600-800 C.E., due in large measure to the efforts of K'inich Janaab' Pakal, who ruled from his 12th birthday for 68 years (remember that the Mayans' average lifespan was only 37 years). Pakal constructed the hugely grandiose Templo de las Inscripciones surrounding and enclosing the 6.93 m^3, thirteen-ton sarcophagus (carved from a monolithic stone block) in which he would be buried. Archaeologists named this 21 meter high pyramidal edifice "The Inscriptions," because of the 617 interior wall glyphs which describe the divine rights of kings, their relations with the gods and their inherited privileges, and dated reports of important events during Lakanhá's history.

Still partially overgrown by the rain-fed tropical forest, the plaza and buildings named Grupo de las Cruces (or Plaza del Sol) form an architectural calendar, built on a world axis, east-west alignment (Figure 2). We climbed the 21-stepped entranceway of Templo del Sol, dedicated to the Sun (Lord of War) and the Jaguar (Lord of the Underworld), examining the painted glyph on the western inner wall of the sanctuary. Only the dawning equinox sunrise stabs it with light.

Palenque's late discovery by the Spaniards in the mid-1700s had protected it from the

zealot-driven cultural destruction wrought by a conquering foreign government and religion in the early 1500s. Continuing excavations, decipherment of glyphs, and archaeozoologic and ethnographic studies will provide a better understanding of this culture's interrelationships with their marine and terrestrial environments, and among themselves. The Classic Mayans' intensive collection and use of marine molluscs may help develop modern methods of sustainable clam cultivation and production, a common theme among many of the XI RENAMAC presentations.

Joint Meeting Announcement, 2011

The XII RENAMAC will be held in June 2011, in La Paz, Baja California Sur, jointly with the 44th Annual Meeting of the Western Society of Malacologists. The coinciding President for both societies will be Esteban Félix Pico. Already being planned are an all-day Symposium on the History of Malacology in Baja California and, of course, field trips by land and sea to research molluscs ecologically in situ or in delicious repasts.

This will be the second meeting of the WSM in this pearl-laden peaceful city on the shores of the southern Gulf of California. Our Society's 40th meeting was held there, under the Presidency of Dr. Carlos Cáceres Martínez, and detailed in WSM Annual Report (March 2009) for 2007, vol. 40, and Bertsch, 2007, *The Festivus* 39: 97-100. Research in the region by WSM charter members A. Myra Keen and Allyn G. Smith (e.g., their 1961 publication on the bivalve sacoglossan opisthobranch *Berthelinia*) may have presaged our Society's recent presence in La Paz.

Figure 1. Group photograph (courtesy SMMAC).

Figure 2. Student poster award winners and professors (from left to right). Back Row: Dr. Esteban Félix Pico, Berenice Grisel Martínez Vázquez, Julio Magaña Cubillo, Dra. Martha Reguero Reza, Dr. Hans Bertsch, Orquidea Lozada Flores, and Jazmín Deneb Ortigosa Gutiérrez. Middle Row: Dr. Luis José Rangel Ruiz, Dr. Roberto Cipriani, Ana María Rivera, Brian Urbano Alonso, Isaura Rebeca López, Iris Dinorah García Tello, and Jorge Luís Gárces Salazar. Front Row: Jaquelina Gamboa Aguilar, Dr. Luis Alfonso Rodríguez Gil, Dra. Edna Naranjo García, and Andrea Zamora. (Photo by Rosa del Carmen Campay. We thank Luis José Rangel Ruiz and Jacquelina Gamboa Águilar for providing the names of the student poster award winners.)

Figure 3. Members of XI RENAMAC at the Templo del Sol (an equinox archaeoastronomical site), Mayan ruins of La Palenque, Chiapas (from left to right). Standing: Esteban Félix Pico, Blanca E. Buitrón Sanchez, Miguelina Morales García, J. Emilio Michel Morfín, Martha Reguero Reza, Roberto Cipriani, Lilia Y. Rendón Díaz, Edgar Heimer de la Cotera, Luis Alfonso Rodriguez Gil, and Our Guide. Kneeling: Catalina Gómez Espinosa and Rosa del Carmen Campay. (Photo by Hans Bertsch)